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WEEKLY October 3 - 9, 2015

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Climate change is killing the autumn

TIRED AND EMOTIONAL

Why sleepless nights lead to short fuses

DEFINITELY MAYBE

Time to get rid of probability

DIRTY TRICKS, DIRTY AIR The true toll of exhaust test cheats

AM I NORMAL?

The inside guide to what goes on in other people's heads



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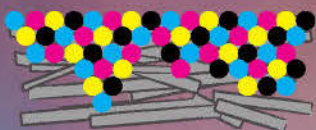
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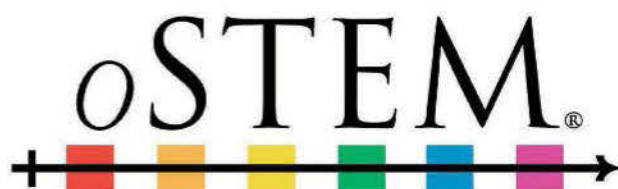
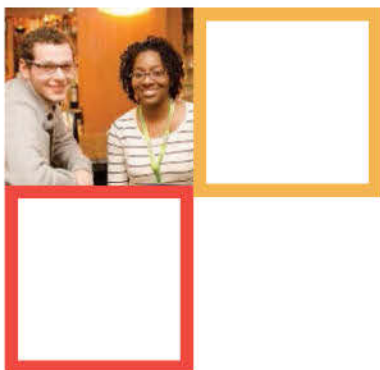
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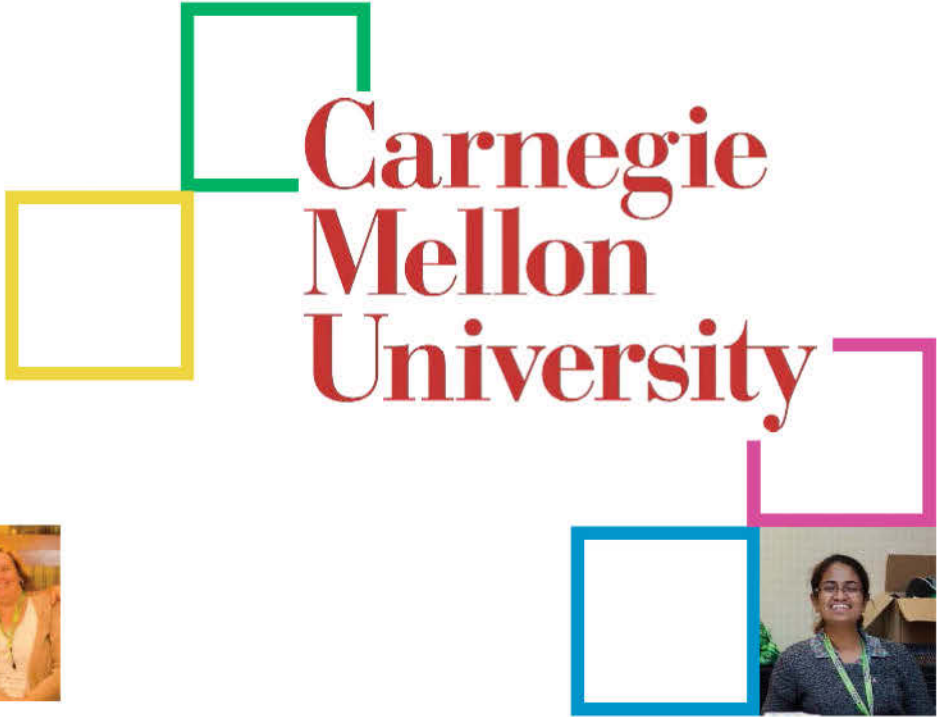


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DARREN HOPES

No such thing as normal

We should take care to nurture neurodiversity

AM I normal? It's a question that most of us ask ourselves at one time or another. We are troubled by inner voices or strange little obsessions; we worry that we are different, that we have weak powers of concentration or poor self-control. But without direct access to other people's thoughts, we have only the vaguest hopes of knowing.

Science has given us ways to know. We can assess mental states and abilities using techniques ranging from psychological tests to MRI scans. These offer us a chance to compare ourselves against others, albeit quite crudely. And we see substantial variation, rendering the very idea of "normality" moot (see page 32).

That is both good and bad news. It should make the idea of being an outlier less worrying. But, ironically, it may also reinforce the idea that certain styles of thinking are better or more desirable than others – and hence that there is a norm to which we should all aspire. Such norms can make it harder to accept and assimilate diversity.

This may become an issue as assessments of mental function become routine. Indeed, we may already be seeing the start of it through psychometric testing in schools and workplaces, rising use of cognitive-enhancing drugs and the medicalisation of behaviour once simply thought of as quirky.

There is a case to be made that

focusing on "normality" obscures the positives of thinking differently. Leaf through the annals of art, science or literature and it is striking how many great figures are described as eccentric, awkward or absent-minded. We owe a great deal to those who think differently from the norm.

That is one reason to celebrate the rise of the neurodiversity movement, an offshoot from autism activism. Many schools and some employers have adjusted their environments to utilise the skills and cater to the needs of the non-neurotypical. Social events are following suit. Let's hope we continue to learn that it is normal, and indeed, good, to be different. ■

Mismeasuring metrology

IF YOU can't measure it, you can't manage it. That dictum runs through our society, from public health to education. It applies especially to science. Innumerable experiments conducted every day depend on precise measurements that ultimately rest on just a handful of standard units.

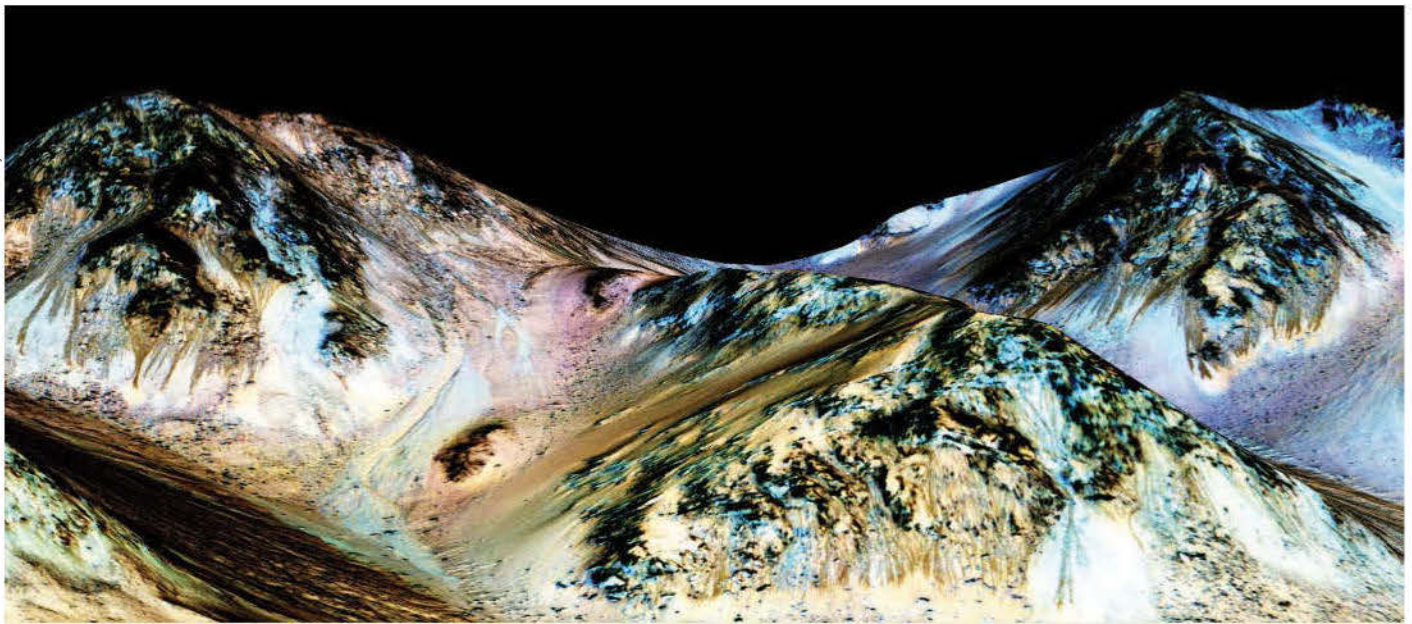
These are now specified with astounding precision, but those charged with their maintenance

still aren't satisfied – for good reason. For example, the lumps of metal that define the kilogram vary by up to 50 micrograms, an embarrassingly large error. Hence their quest to tie all units to fundamental particles and constants (see page 38).

The branch of science behind this, metrology, is often dismissed as tedious, but there is reason to think that it is about to become

very interesting. Now that metrologists are making measurements on particles like photons and electrons, they are entering the quantum realm where measurement itself is a poorly defined concept.

What this means has divided physicists for almost a century (see page 30). But new experiments and techniques have always been the harbingers of revolution: perhaps metrology can finally give the quantum philosophers something new to talk about. ■



Saltwater streaks found on Mars

IT'S a flow chart from another world. NASA's Mars Reconnaissance Orbiter has found the best evidence yet that liquid water streams along the planet's surface during warm seasons.

Recurring slope lineae (RSL) – dark streaks that appear, grow and then fade each Martian year – were discovered in 2011, and appeared to signify flowing water. Now data from the orbiter's spectrometer, which can help identify surface minerals, would appear to back that idea.

Spectral measurements from four RSL sites reveal the presence of hydrated salts – probably magnesium

perchlorate, magnesium chlorate and sodium perchlorate – that can absorb water from the atmosphere and lower its freezing point, letting it stay liquid even in Mars's cold climate (*Nature Geoscience*, doi.org/7xw).

The Curiosity rover may be able to check out similar streaks, although the terrain may prevent it getting up close. Earlier this year, Colin Dundas of the US Geological Survey and colleagues observed features resembling RSL in Gale crater, where Curiosity landed.

"All of the activity that we've seen has been on steep slopes that would be difficult for the rover to access, but

Curiosity's cameras will be able to watch for changes," Dundas says. Curiosity has already found evidence of perchlorates at Gale crater, as well as organic compounds.

Whether or not these damp flows could sustain life depends on how salty they are, says study co-author Lujendra Ojha of the Georgia Institute of Technology in Atlanta. Water saturated with salts would be hostile to life, but just a trace "should be fine".

But fellow team member Alfred McEwen of the University of Arizona, Tucson, is less sanguine. "If I were a microbe on Mars, I wouldn't live

near one of these RSLs," he says. "We think there is subsurface fresh water nearer the poles."

The find is likely to reignite debate over how to search for life on Mars, and even whether a search is worth it. Some astrobiologists criticised NASA when plans for its future Mars 2020 rover left out DNA sequencers and other instruments designed to look for living organisms.

But others think Mars is probably a dead world, and that it would be more fruitful to search in the subsurface oceans of Europa, one of Jupiter's moons, or Enceladus, one of Saturn's.

New DNA slicer

WHO owns the biggest biotech advance of the century?

Geneticists in Boston may have found a way around a high-stakes patent dispute over one of the most significant biotechnology breakthroughs in recent years, a gene-editing tool called CRISPR.

CRISPR is faster, easier and cheaper than other gene-editing techniques. But the technology is

embroiled in a patent dispute between researchers in California and Massachusetts.

Last week, one of the teams, led by Feng Zhang at the Broad Institute of MIT and Harvard, announced a potential workaround: two novel DNA-

"The discovery has the potential to sidestep a patent dispute, freeing up money for research"

slicing enzymes that can replace the one at the centre of the legal spat. Zhang's team has used the enzymes to successfully edit human genomes (*Cell*, doi.org/7zw).

The discovery could potentially sidestep the patent dispute, freeing up money for research that might otherwise be spent on legal proceedings.

"It's an important discovery in an important field," says Daniel Anderson at MIT.

Smoking genes

IS THERE smoke without fire? Some smokers seem to be spared the lethal effects of tobacco, and the UK Biobank might know why.

The biobank opened in 2012 and it contains detailed health information on 500,000 middle-aged volunteers. Martin Tobin at the University of Leicester, UK, and colleagues analysed 50,000 volunteers' DNA – including non-

smokers and heavy smokers.

They identified six genes that seem to have a role in lung health. While some people appear to have protective versions, others may have one or more harmful kinds. This might explain why some heavy smokers don't develop chronic obstructive pulmonary disease – a group of disorders that together form the third most common cause of death worldwide (*The Lancet Respiratory Medicine*, doi.org/7zn).

But Tobin warns that smokers' lung function will still be weaker, even if they are disease-free. "There is no real green light here."

Big Apple floods

THOUGHT superstorm Sandy was bad? Brace yourself. The floods that used to soak Manhattan in New York every 500 years now come every quarter-century.

Storms can cause flooding by temporarily increasing sea levels. The severity of flooding depends on the height of this "storm surge" and the baseline sea level. So Benjamin Horton of Rutgers University, New Jersey, analysed sediment samples from local salt marshes to see how the sea level changed between 850 and 2005. His team then used climate models to generate hypothetical cyclones.

They focused on an area in Lower Manhattan known as the Battery, where the sea walls were breached during superstorm Sandy. They found that average flood heights there increased by 1.2 metres between 850 and 2005 (*PNAS*, doi.org/10/7zk).

The figures showed that before 1800, one storm every 500 years would have produced a 2.25-metre storm surge in the district; now, such storms occur once every 24 years. "You can really see the impact of anthropogenic activities," Horton says.

The main reason for higher storm surges is raised sea level. But the models also showed a rise in more extreme kinds of storm.

Fish gobble plastic

IT'S not what you want in your seafood. Fish caught off the coasts of California and Indonesia have plastics and textile fibres in their guts, raising food safety concerns.

Chelsea Rochman at the University of California, Davis, and her team visited local markets and sampled 64 fish from a dozen Californian species, and 76 fish from 11 Indonesian species. They found artificial debris in around a quarter of the fish and more than half of the species, including varieties of mackerel and herring in Indonesia and Chinook salmon

and Pacific anchovy in California (*Scientific Reports*, doi.org/7zi).

The debris was mainly textiles in the US fish, and plastic in the Indonesian fish. Rochman says this may reflect differences in waste management: the US

"Affected fish included Indonesian mackerel and herring, and Pacific anchovy in California"

recycles more plastics but also produces more washing machine effluent. It's not yet clear if any chemicals from the gut debris can contaminate fish flesh.

Shell quits Alaska, stays in Arctic

THEY came, they drilled, they gave up. In a surprise move, the oil giant Shell this week announced a halt to oil and gas exploration under the Chukchi Sea, off the coast of Alaska.

"The decision is purely commercial," a spokeswoman told *New Scientist*. Initial exploration yielded too little oil to be profitable. "Shell will now cease further exploration activity in offshore Alaska for the foreseeable future."

Shell had sunk some \$7 billion into the project. It suspended activity in 2012 because of environmental concerns, then resumed exploration earlier this year amid strong opposition, most recently from presidential candidate Hillary Clinton.

Many concerned observers are

thrilled. "In terms of keeping the Arctic pristine, it's a big win," says Malte Humpert of the Arctic Institute, a think tank based in Washington DC. "For the American Arctic, it could be the end of the story for quite a while."

But Shell's withdrawal from Alaska hasn't dented its activities elsewhere in the Arctic. It has licences to explore in Greenland, Russia and Norway. "We already have an operation with the Russian firm, Gazprom, to explore in the Russian Arctic around Sakhalin Island," said the spokeswoman.

Compared with Alaska, some of those oilfields are closer to target markets, have more onshore fields and less sea ice, so it may be easier for Shell to make drilling pay there, Humpert says.



Protests paid off, the drilling didn't

60 SECONDS

Quantum contract

Google and NASA have struck a deal with Canadian quantum computing company D-Wave to keep them stocked with hardware for at least the next seven years. D-Wave claims its current tech is up to 15 times faster than regular computers. Quantum computers could help create better algorithms for complex problems like air traffic control.

Walrus whodunnit

Alaskan officials are investigating a grisly crime near Cape Lisburne, where 25 walruses – including a dozen calves – were found shot and beheaded. Native Alaskans can kill walruses for food, but killing them just for their tusks is against the law.

Blindness treatment

Eye surgeons in London this week successfully treated the first of 10 British patients, using a tiny patch of tissue originating from stem cells to restore sight lost through macular degeneration. The patch is a variant of similar treatments pioneered in the US in 2011 that have already partially restored sight to some people with macular degeneration.

Croc hybrids in Belize

Holiday-makers in Belize may be driving hybridisation between freshwater Morelet's crocodiles and marine American crocs. DNA tests show the two species are interbreeding in the country's south, possibly because land taken by tourism is displacing the vulnerable American croc females from their preferred nesting sites (*Royal Society Open Science*, DOI: 10.1098/rsos.150409).

Kiwi marine protection

New Zealand has announced that it will create one of the world's largest marine protected areas north of its mainland. The Kermadec Ocean Sanctuary will cover 620,000 square kilometres of the South Pacific Ocean, containing many whales, dolphins, fish and sea turtles.

Mocking up the universe

Cosmic simulations help us get ahead of real-world observations, finds **Joshua Sokol**

A SUPERNOVA has exploded in a galaxy not unlike our own. The photons unleashed will travel for billions of years through vacuum, dust and Earth's atmosphere before being focused on to a telescope. From faint specks in blurred pictures, astronomers will use that supernova and many others to gauge the strength of dark energy, the mysterious force stretching our universe apart.

Only this isn't our universe. It's a giant fake – a simulation with a known amount of dark energy plugged in at the beginning. As if checking their answers against the ones in the back of the book, researchers compare the programmed strength of dark energy against that measured from the mocked-up images the virtual telescopes create. The difference between the two will let astronomers refine their real-world methods and help the hunt for dark energy in the real universe.

The telescope that will benefit from this cosmic charade is the Large Synoptic Survey Telescope (LSST), which will look for dark energy and more for real atop a Chilean mountain from 2022. But such experiments are finding uses in all areas of astronomy.

"I would describe them as test universes," says Rachel Mandelbaum of Carnegie Mellon University in Pennsylvania. "We can test that our analysis algorithms are able to remove all the junk we don't care about."

That leaves what we do care about – and not just dark energy. Similar simulations are now being used to probe the equally elusive dark matter, which is thought to make up the bulk of the universe's

mass yet scarcely interacts with regular matter; star-forming nebulae; gravitational lenses; and other cosmological quandaries (see "Mini Multiverses", below right). It's an entire fake multiverse that astronomers can spar with before going out to face the real thing.

Test universes

Of course, the simulations didn't get this good overnight. For decades, cosmologists have turned to simulations when the interplay between objects got too complicated – and tedious – to solve with pen and paper. One of the first was in the 1970s, when brothers Juri and Alar Toomre collided two galaxies represented by ASCII characters to try to explain the bizarre real-world Antennae Galaxies, which look like a contorted question mark. A video camera, pointed at the monitor as the simulation crunched through frame after frame, recorded the action to show that a galactic merger yielded a crude version of the galaxies' shape.

The intervening years have seen ever-bigger and more accurate simulations on supercomputers. "What you have had is progress on three fronts: the speed of computers, our algorithms and our understanding of physics," says Paul Torrey at the Massachusetts Institute of Technology.

In 2005, for example, the Millennium simulation generated about 20 million galaxies in a virtual cube 2 billion light years to a side. Torrey is a member of



NASA, ESA, N. SMITH (UNIVERSITY OF CALIFORNIA, BERKELEY), AND THE HUBBLE HERITAGE TEAM (STSC/AURA/UCSD)

MINI MULTIVERSES

Making observations in simulated universes is helping astronomers perfect techniques before trying them out in the real world, by letting them compare what is measured with the answer that was programmed in (see main story). That approach is shedding light on some of the most pressing problems in the cosmos:

DARK MATTER

Very slight warps in the shapes of galaxies we see across the sky can show us where dark matter is hiding – but only if we interpret those distortions correctly. Simulations are helping us figure out the best way to pick up and trust in this subtle effect.

STAR-FORMING NEBULAE

The gas and dust in stellar nurseries, where stars blast their surroundings with ultraviolet light, is too diffuse to recreate in a physical experiment. But simulations are possible, helping us

translate between what we observe and the chemistry at play. This can show us the gas that stars coalesce from and the grains of interstellar dust that can grow into planets.

EXOPLANETS

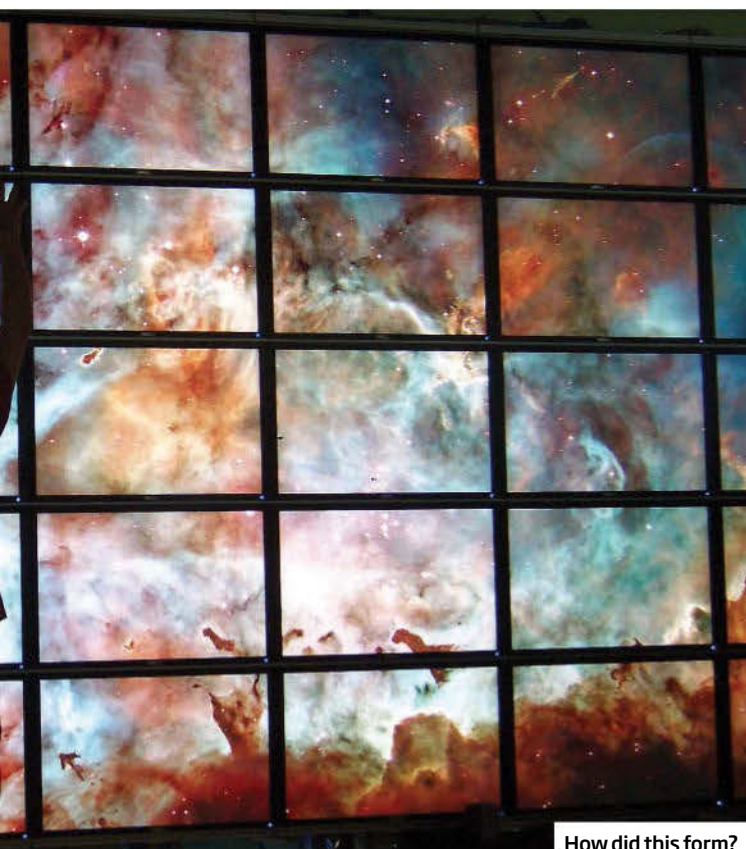
Models of what possible multi-planet systems would appear like through NASA's Kepler telescope are being used to look back through Kepler's catalogue to help find previously undiscovered worlds that may resemble Earth.

REFINING SIMULATIONS

In a weird twist, citizen scientists volunteering with the Galaxy Zoo project are classifying both real galaxies and ones from the Illustris simulation by shape to see how they differ. The results will feed into future simulations, making their galaxies resemble real ones even more closely.

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How did this form?

the ongoing Illustis simulation, which also aims to make a universe from scratch in a jar. Illustis includes not just dark matter, but the devilishly complex motions of gases.

"Experiments for the most part are just not possible to us," Torrey says. "How do you understand not just the current state of objects, but where they came from and where they're going? Simulations allow us to fast forward and rewind."

While these efforts to build a cosmos continue, in the past few years we have seen another use for such simulations: donating fake galaxies to be used as predictive tools for other projects.

The LSST is a prime example. As the actual telescope slouches to completion, simulations are already lighting the way forward.

When it's up and running, the telescope will map the entire sky every few nights for 10 years, transforming the cosmos into a

huge database. It will probe dark energy by looking at distant supernovae, weigh dark matter from the distorted shapes of background galaxies, and track potentially dangerous asteroids.

But Andy Connolly, who runs LSST's 10-person simulation team at the University of Washington, doesn't want to wait to see the universe through the LSST's eyes.

"It's a fake multiverse that astronomers can spar with before going out to face the real thing"

The simulations Connolly has planned will take tens of millions of hours of processing time on supercomputers. They all start with galaxies from the Millennium simulation. Every step the photons take from those galaxies to a telescope on a virtual Earth, and the creation of simulated maps of dark matter and dark energy, is meticulously

traced. All that effort is needed because each intervening step distorts the original signal.

"It's a simulated view of a perfect representation of the universe," Connolly says.

Simulations have already helped sharpen our search for dark matter. In 2013 and 2014, Mandelbaum led a challenge – the third so far – in which algorithm was pitted against algorithm to see which made the best map of how gravity distorted images of mocked-up galaxies compared to the "true" answer. And modelling efforts are also planned to help NASA's upcoming Wide-Field Infrared Survey Telescope, which will look for dark matter and dark energy.

But even as this kind of test comes into wide use, the idea of learning about reality from a fake universe still feels risky. "It's dangerous to say: I generated a simulated observation that looks like what I see through a telescope, and this looks like reality," says Matthew Turk at the National Center for Supercomputing Applications in Illinois. Since we are counting on simulations to teach us about our scientific methods, trusting the wrong one just because it can make realistic-looking galaxies could lead us to misleading measurements.

Turk is part of the yt Project, an open software collaboration that he hopes will help scientists from all over astronomy weigh up their models. Currently, simulations are often run with incompatible software, and researchers don't always think about how their mocked-up observations can be compared with real data.

Setting a standard is now more crucial than ever, says Turk, especially as astronomy comes to depend on them more and more. "Just doing an awesome simulation is so far removed from contributing to scholarship," he says. "We need to be very careful about which wheels we decide to reinvent." ■

Fossil ear bones reveal shift in human hearing

NOW hear this. A reconstruction of fossil ear bones has found that human hearing shifted towards picking up frequencies useful in speech very early in our evolution.

Rolf Quam of Binghamton University in New York and his colleagues studied skulls and ear bones from *Australopithecus africanus* and *Paranthropus robustus*, which lived between 1 million and 3 million years ago, as well as those of modern humans and chimps.

Using CT scans, they built 3D models of the ears of each species. Then they used chimp and human anatomical data to work out what frequencies these ears could pick up. Modern humans and chimps perform similarly below 3 kilohertz, but we have better hearing in the 3-5 kHz range. The early hominins had a similar range to chimpanzees, but shifted slightly towards that of modern humans, with better hearing around 3-4 kHz (*Science Advances*, doi.org/7w6).

Australopithecus and *Paranthropus* are not believed to have been capable of language, which evolved much later, but like other primates they almost certainly communicated vocally, says Quam.

He thinks the shift in hearing sensitivity would have helped them communicate in open environments, where sound dissipates quickly. "Their auditory pattern would have been beneficial if they were moving out on to the savannah and engaging in short-range communication."

Consonants are a distinctive feature of human language and many, such as t, k, f and s, contain sounds in the 3-5 kHz range. Being able to hear these better might have been a precursor to more sophisticated vocalisations.

Being able to hear certain frequencies doesn't mean you can speak, says Robin Dunbar at the University of Oxford. "All this tells us is that the frequencies used in speech perception and production have a very early ancestry." Sam Wong ■

The curious case of NO_x pollution

We knew air pollution was inexplicably high before the VW scandal. Are cars to blame?



JULIAN STRATENSCHULTE/DPA/CORBIS

Not so squeaky clean after all

Andy Coghlan

VOLKSWAGEN'S admission on 22 September that it rigged emissions tests could throw light on why some major European countries have failed to meet air pollution targets.

Failure to reduce levels of airborne nitrogen oxides (NO_x) may mean more premature deaths and a higher disease

burden (See "The death toll", right).

VW cheated by fitting its cars with a "defeat device", a component designed to recognise when an emissions test is under way and adjust the engine's performance (See "How did Volkswagen rig emissions tests?", far right). VW's CEO resigned over the scandal which is said to have affected 11 million cars, including VW, Audi, Skoda and Seat models.

An investigation by *New Scientist* suggests that no other manufacturer of diesel vehicles has gone as far as VW to pass the tests. But there may be many that legally deploy unrealistic conditions during testing to

"New emissions tests that reflect real driving conditions could be rolled out as soon as 2017"

reduce strain on the engine and with it the emissions produced.

The aim is to find a performance sweet spot that maximises the apparent fuel efficiency of the vehicle and minimises its emissions, even if both deviate from how the car performs in the real world.

Strategies to reduce strain on the engine could include increasing the tyre pressure or turning off the air conditioning and heating.

1001 tricks

"None are as extreme as what VW did, but there are 1001 tricks you can play to reduce emissions during the test," says Alastair Lewis of the University of York, UK. "The key is to accelerate as slowly and smoothly as possible to put the minimum load on the engine."

Martin Adams, head of the air pollution group at the European Environment Agency (EEA), says it is already well known that on-road fuel consumption and emissions can be significantly higher than official test measurements indicate. "The amount of fuel cars use on the road can be 30 per cent or more higher than official measurements. For NO_x, the differences are even greater, particularly for diesel vehicles, with real-life measurements showing that emissions can be as much as four or five times higher than in the test."

"There have been rumours that some vehicles 'know' they are being tested," Adams says, "but this is the first time it has been confirmed."

If this practice is widespread, it could help explain why NO_x emissions in many European countries continue to overshoot targets (see map, above right). Transport accounts for 46 per cent of all NO_x emissions in the region, according to the EEA.

EEA figures show that European Union member states have struggled to meet NO_x limits set

Air pollution hotspots

By 2010, the mean yearly nitrogen dioxide level was supposed to be below 40 micrograms per cubic metre of air in the EU. It was higher in many sites in 2012

● 40-49 ● >50 $\mu\text{g}/\text{m}^3$ NO_2



in European legislation in 2008 on the basis of what manufacturers said they could achieve technologically. By 2010, 11 of the 27 countries then in the union had failed to reach the target, and six still hadn't by 2013, including France and Germany, the home of VW. The limit is 40 micrograms per cubic metre of air.

"In 2013, Germany and France

reported the highest exceedances of NO_x limits, with 218 kilotonnes and 180 kilotonnes respectively," the EEA reported in June. The two countries were also the major overshooters in 2010. Austria, Belgium, Ireland and Luxembourg have also been persistent offenders.

We don't know whether manufacturers' strategies have contributed to the unexpected failure of countries to reach NO_x targets, Adams says. It is one possibility, but there are other explanations.

One is the growth in overall traffic, and another the increase in cars that burn diesel instead of petrol. Diesel cars release less carbon dioxide than petrol cars, but they currently account for 80 per cent of all vehicle NO_x emissions, according to EEA estimates.

New, more realistic tests have been developed and agreed, Adams says. "The sooner they are in operation, the better. It's now down to timing. It could be as soon as 2017, or as late as 2021." ■

THE DEATH TOLL

We know that nitrogen oxides (NO_x), especially the nitrogen dioxide (NO_2) discharged from car exhausts, are indirectly harmful. They contribute to the production of ozone and fine particulate matter, both of which harm human health.

According to estimates by the European Environment Agency, in 2011 ozone was the cause of about 16,000 premature deaths in the European Union, and particulate matter could be attributed to around 430,000 deaths.

But it has been difficult to establish whether NO_2 itself is harmful. That is changing, says Martin Williams of King's College London. "Now, there is much stronger evidence for independent effects of NO_2 ."

An investigation by the World Health Organization in 2013 found that NO_2 is a hazard to health in its own right. The gas aggravates heart

and lung disease, says Martin Adams, head of the air pollution group at the EEA. A UK government document published last month estimated that up to 23,500 deaths in the UK can be attributed to NO_2 each year. The Europe-wide impact of NO_2 hasn't yet been established, Adams says.

The switch to diesel vehicles is making things worse: their engines produce more NO_x than those that run on petrol. What's more, around 70 per cent is in the form of NO_2 , compared with only 10 to 15 per cent when petrol is burned. NO_x levels in many European cities are higher than the EU limit of 40 micrograms per cubic metre of air (see map, above).

Proposed solutions include a ban on diesel vehicles in cities or the creation of clean air zones, fuel duty to discourage diesel use, and monetary incentives for switching to electric or hybrid vehicles.

How did Volkswagen rig emissions tests?

VOLKSWAGEN has been cheating the emissions testing system to make its diesel cars seem less polluting than they really are. But how did it do this?

New vehicles have to meet ever stricter emissions standards for a range of pollutants, but the testing is done in a lab rather than on the road. Volkswagen programmed its on-board software to detect when cars with its TDI diesel engine were undergoing an emissions test, using information from the steering, brakes and accelerator. It then tweaked the engine settings to minimise levels of nitrogen oxides (NO_x). On the open road, NO_x emissions are up to 35 times higher. Up to 11 million vehicles made from 2009 onwards may be affected.

It is not yet clear exactly what this software does, but we can make an educated guess. There are two main ways to reduce NO_x emissions: minimise their production or remove them from exhaust fumes.

More NO_x is produced when the temperature inside the engine cylinder is high and there is plenty of oxygen available. One way to tackle this is to circulate some of the exhaust gas back into the engine, which reduces both temperature and oxygen levels. All VW TDI diesel engines are fitted with exhaust gas recirculation systems.

A similar effect can be achieved by closing the exhaust valves early, so some exhaust gas remains in the cylinder. Another strategy is to increase the fuel-to-air ratio, leaving less oxygen to react with nitrogen to form NO_x .

As for reducing NO_x from the fumes once produced, modern diesel engines also have either a lean NO_x trap (LNT) or selective catalytic reducer (SCR) fitted to the exhaust.

There are drawbacks to all these approaches. Recirculating exhaust gas, unsurprisingly, reduces engine performance. LNTs work by absorbing NO_x but they rapidly become saturated. They have to be regenerated every few seconds by



Unrealistic setting

pumping extra fuel into the engine, which increases fuel consumption.

SCRs work by injecting urea into the exhaust, which reacts with nitrogen oxides, forming harmless nitrogen gas and water. Car owners have to refill the tank of urea (sold as AdBlue) every few months. It also takes up space, so SCRs are only fitted in larger vehicles.

VW's cheat must involve adjusting some of these NO_x -reducing measures. In theory the software could be reprogrammed, but for cars that do not have SCRs, there could be a major impact on performance and fuel consumption. If courts and regulators deem this performance hit unacceptable, the huge bill facing the car maker will soar even higher.

One solution would be to retrofit SCRs to these vehicles. But it would require major modifications,

"On the open road, vehicle nitrogen oxide emissions are up to 35 times higher than in tests"

and car owners may well object. Instead, Volkswagen could end up having to refund customers, or replace their vehicles.

The European Union was already planning to introduce so-called realistic driving emissions tests, using portable equipment to measure the emissions of new car models on real roads, rather than in the lab. These tests are now likely to be introduced sooner rather than later, with less sway from the industry to delay them. Michael Le Page ■



Aiming for the not-so-Red Planet

I moss say, life on Mars is a breeze

Aviva Rutkin

A PACKING list for future planetary pioneers: water, rations, spacesuit... moss?

At the University of Copenhagen in Denmark, student researchers imagine an ambitious future for the little plant. They are working on a new line of moss, changing its DNA to prepare it for life in a harsh Martian environment.

The students were inspired by TychoBio, a Copenhagen start-up that has genetically engineered moss to make chemicals such as ingenol mebutate, a treatment for skin cancer. The team wondered whether moss could manufacture medicines for astronauts.

Humans are entering a realm of exploration in which we want to go to Mars and look at other planets, says team member Victoria Sosnovtseva. "Why don't we use moss to make components that are useful for space exploration?"

But first it must survive on Mars, where the dirt is nutrient-poor and full of poisonous salts. In one experiment, the team

planted moss in soil taken from Pu'u Nene, a volcanic cinder cone in Hawaii. Although that soil isn't quite as bad as the stuff on Mars, studies performed by NASA's Curiosity rover have found that the two have similar mineral compositions. After several weeks, the moss seemed fine, bolstering the team's confidence that it could handle Martian soils.

Extreme cold is another challenge. The average temperature hovers around -55°C on Mars, so the researchers

"Why don't we use moss to make components that are useful for space exploration?"

spliced an "antifreeze" gene into the moss. The gene is borrowed from the spruce budworm, a pest that lives in coniferous trees. It produces a protein that inhibits the formation of ice crystals, keeping the worm safe from freezing temperatures. That same skill, they reasoned, could come in handy for interplanetary moss.

The team put the new moss in a freezer for 8 hours and found that it thrived at -20°C , whereas normal moss died. But at -60°C , although a few live cells were spotted, it's not clear that they could handle a long stint on Mars.

The work was presented last weekend at the Giant Jamboree of the International Genetically Engineered Machine Foundation in Boston.

Growing plants on Mars could be feasible and even desirable, says Rocco Mancinelli, an astrobiologist at the SETI Institute in Mountain View, California, who has explored how wheat might fare on the Red Planet. His team found that the greatest obstacles to growth are the low atmospheric pressure of oxygen and the limited water available.

He cautions that the space-moss team needs to keep these factors in mind. "To focus on microbes and temperature is being too narrow," he says.

The team agrees that there's a long way to go before the moss is space-ready. In the future, they'd like to add in other genes to help protect against UV radiation, or to break down salts in the dirt.

"It would be supercool," says team member Jonathan Arnesen, if astronauts could one day "plant the moss directly on Mars soil". ■

Deepest quakes hit in surprise seasonal cluster

SOME earthquakes seem to hit in a seasonal pattern – and no one knows why. "Physically, it doesn't make any sense," says Zhongwen Zhan.

Zhan, of the Scripps Institution of Oceanography in San Diego, California, and his colleague Peter Shearer examined a global catalogue of earthquakes that have occurred since 1900. Out of 60 large, deep quakes in the catalogue, 42 hit between April and October. The trend doesn't appear in shallower or smaller quakes, but stands out clearly for those above magnitude 7.0 and at a depth greater than 500 kilometres (*Geophysical Research Letters*, doi.org/7w7).

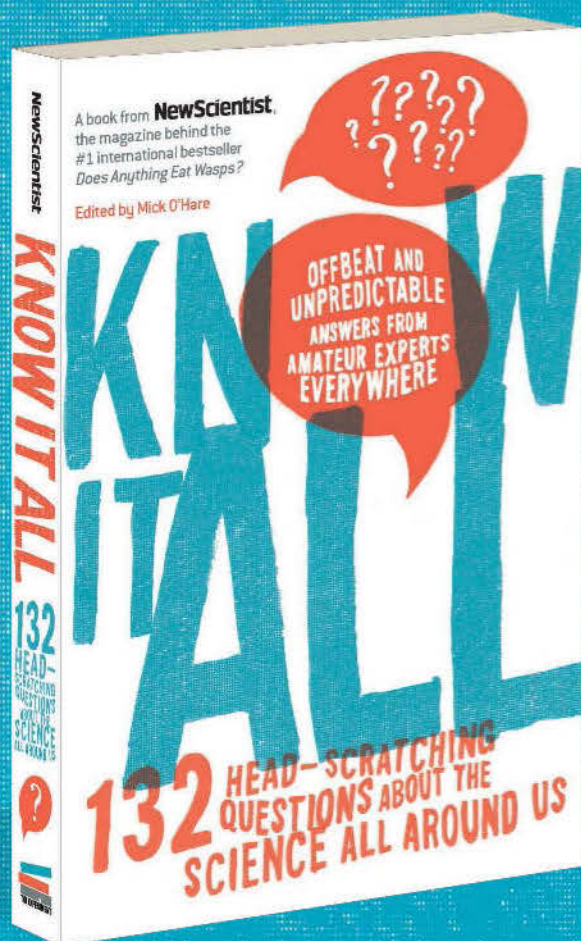
The seasonality could be related to the tidal forces felt by Earth due to the sun's gravity, Zhan says, or to a wobble in Earth's rotational axis due to seasonal sloshing of water and air around the planet.

The solar tides may help explain how earthquakes happen at all at such depths, where the rocks are under high temperatures and pressures that render them soft and pliable – and unlikely to suddenly rupture, causing a quake. "The high pressure makes people think there shouldn't be any earthquakes," says Zhan.

Although Zhan's methods are sound the result may only be a statistical aberration, and may lack a physical mechanism, says Cliff Frohlich of the University of Texas at Austin. "If you're searching for some possible explanation, the solar tide would be your candidate. But it's not a very strong candidate because it's not a very strong tide," he says. As early as the 1930s, geologists claimed to have found a seasonal trend in earthquake activity. Often, as new data comes to light, the correlations weaken, he adds.

Zhang says it will take a few more decades of new data to see if the seasonal trend is more than chance. A confirmed trend may lead to a better understanding of how quakes are triggered and hence better prediction tools, Zhan says. Paul Gabrielsen ■

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No neutral gear for the sleep-deprived

Jessica Hamzelou

DARK puffy eyes, a feeling of deep exhaustion, and a foul mood to match – all of us have experienced the side effects of a lack of sleep. But exactly why sleep is so important for our well-being remains a mystery.

Talma Hendler of Tel Aviv University in Israel is particularly interested in how being short of sleep leaves us with a short fuse. “We know that sleep affects our emotional behaviour, but we don’t know how,” she says.

To investigate, Hendler and her colleagues kept 18 adults awake all night. “It took a great effort,” she says. “During the night, we repeatedly measured their sleepiness, and unsurprisingly they got more and more tired.”

The volunteers had to perform tests, both the day after a good night’s sleep and after being awake for 24 hours. In one test, they saw yellow dots moving on a screen and had to state their direction. The dots were laid over a potentially distracting picture classed as either “positively emotional” (of a kitten, for example), “negatively emotional”

(such as a snake) or neutral (such as a spoon).

When the volunteers were well rested, they performed quickest and most accurately when the background image was neutral. But after a sleepless night, they did just as poorly whether neutral or emotional images were used.

That might simply be because

lack of sleep impairs judgement, but it’s also possible that something more subtle is at work – that it makes us respond emotionally even to neutral images, says Hendler.

To probe the mechanism in more detail, her team conducted a similar experiment with participants in an fMRI scanner to measure their brain activity. They found that when the volunteers had had a good night’s sleep, a region called the amygdala – which plays a part in emotion – fired up only in response to the emotional images. But when they

were sleep-deprived, it reacted to neutral images as well.

The team also found unusual activity in a part of the brain called the anterior cingulate cortex (ACC), which is thought to regulate the amygdala and our emotions. In well-rested people, the two brain regions fired together. But they seemed out of sync when the volunteers were sleep-deprived (*Journal of Neuroscience*, doi.org/7xi).

Together, the experiments suggest that when we are starved of sleep, we tend to see everyday situations as more worthy of attention than normal, says Hendler. “You lose neutrality,” she says. “It’s as if everything is important.”

There is one obvious way to protect yourself from the effects of sleep loss: get enough shut-eye. Hendler thinks people might also be able to improve coordination between the ACC and amygdala using neurofeedback – a technique that uses brain-monitoring technology to allow people to watch and attempt to control their own brain activity.

But Mary Carskadon at Brown University in Providence, Rhode Island, is unconvinced by such interventions. “Despite wishes some have to the contrary, we all need sleep,” she says. “I don’t want to stimulate the activity between my amygdala and frontal cortex – I want to get plenty of sleep.” ■



Even brain scans show I'm touchy

Wikipedia-sized maths problem cut down to size

A MATHS problem previously tackled with the help of a computer, which produced a monster proof the size of Wikipedia, has now been made manageable by a human. Although it is unlikely to have practical applications, the result highlights the differences between two modern approaches to mathematics: crowdsourcing and computers.

Terence Tao of the University of California, Los Angeles, has published a proof of the Erdős discrepancy problem, a puzzle about the properties of an infinite, random sequence of +1s and -1s.

In the 1930s, Hungarian mathematician Paul Erdős wondered whether such a sequence would always contain patterns and structure within the randomness. One way to measure this is by calculating a value known as the discrepancy. This involves adding up all the +1s and -1s within every possible sub-sequence. You might think the pluses and minuses

would cancel out to make zero, but Erdős said that as your sub-sequences get longer, this sum would have to go up. In fact, he said the discrepancy would be infinite, meaning you would have to add forever.

Last year, Alexei Lisitsa and Boris Konev of the University of Liverpool, UK, used a computer to prove that the discrepancy will always be larger than two. The resulting proof was a

13 gigabyte file – about the size of the entire text of Wikipedia – that no human could hope to check.

Tao, with the aid of crowdsourcing, has used more traditional mathematics to prove that Erdős was right: the discrepancy is infinite no matter what sequence you choose (arxiv.org/abs/1509.05363).

Lisitsa praises Tao for doing what his algorithm couldn’t. “It is a typical example of high-class human mathematics,” he says. But mathematicians are increasingly turning to machines for help, a trend likely to continue. Jacob Aron ■

“The proof of the Erdős discrepancy was reached using traditional maths with the aid of crowdsourcing”



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Local microbes can affect the flavour and aroma of wine

RAISE a glass to the real winemakers: yeast. Research is starting to show just how important microbes can be for creating a distinctive taste.

Matthew Goddard at the University of Lincoln, UK, and Sarah Knight at the University of Auckland in New Zealand isolated yeast from six regions and used them to ferment the same batch of grape juice from Sauvignon Blanc fruit, which had been sterilised to kill off any existing microbes.

They then analysed the concentrations of 39 flavour-imparting chemicals in wines produced from the different

yeasts. They found that 29 of them varied depending on where the yeast had come from, suggesting that the local varieties of yeast affect the taste of wine. This explained around 10 per cent of the total variation in the chemical profiles of wines (*Scientific Reports*, doi.org/7v5).

"The microbial component is only one of many influences, so by itself wouldn't weigh in massively," says Goddard. Other big elements come from human factors, such as when the grapes are picked and the blend of grapes. "But we're suggesting here that even though it's a small component it's still a significant component."

Hervé Alexandre at the University of Burgundy in Dijon, France, agrees that soil and climate play a bigger role.

The hawks that hunt together

THEY'RE the world's only raptor pack. Some Harris's, or Harris, hawks (*Parabuteo unicinctus*) in the wild work in teams to chase down prey like rabbits and lizards.

Jennifer Coulson of the Orleans Audubon Society in Pearl River, Louisiana, and her husband – both avid falconers – trained a hunting team of the birds, allowing them to see the unusual behaviour up close.

During the airborne hunt, a single lead hawk will be flanked by wingmen ready to step in if the first hawk dives but misses the target. And if the prey takes cover, some birds sacrifice their chances of making the kill by noisily wading through the bush to force the animal back into the open.

Strangest of all, the birds will hop on top of each other when perched – "like a hawk totem

pole", says Coulson – to afford the top bird a better view.

The hawks share their kills afterwards, but why they cooperate is a mystery. Coulson thinks it might be because they occupy a landscape with few prey animals and lots of cover – team work might be the only way to stay alive (*The Auk*, vol 130, p 548).

Ongoing efforts to study the habitats where the hawks do and don't team up may help shed light on the puzzle.

Paralysed man thinks to walk

A 26-YEAR-OLD man who is paralysed in both legs has walked for the first time in five years – just by thinking about it.

Functional-electrical-stimulation devices activate the nerves in leg muscles at the push of a button. But many people who are paralysed have little sensation in their arms, so can't easily use buttons.

Zoran Nenadic at the University of California, Irvine, and his colleagues developed an electrode cap that detects when a person is thinking about walking or standing still. They tailored it to pick up brain signals from their volunteer – a man who has had little sensation below his shoulder blades for five years.

"He walked 1.8 metres to a traffic cone, could stop for 30 seconds, and then continue the length of a 3.6-metre course," says Nenadic (*Journal of Neuroengineering and Rehabilitation*, doi.org/7wc).

Two became one to form comet 67P

CRASHING in slow-mo. The Rosetta spacecraft has confirmed that comet 67P/Churyumov-Gerasimenko was formed by two small bodies coming together at less than walking speed.

Matteo Massironi, a geologist at the University of Padova, Italy, and his colleagues have studied high-resolution images of the comet. Layers of material – called strata – are visible, but their 3D arrangement makes them look like two onions stuck side by side. This confirms that the comet was once two separate rocks.

The strata of 67P could only be preserved if its two halves collided at about 1 metre per second – a little slower than most people walk (*Nature*, DOI: 10.1038/nature15511).

America's oldest decapitation

GETTING ahead in more ways than one. Archaeologists have found the 9000-year-old skull of a decapitated middle-aged man in Brazil. The nature of the find suggests the man was venerated by his peers.

The team found the man's two detached hands covering the skull's face – one pointing up and the other down. The care with which the skull and hands were placed suggests respect rather than punishment, says André Strauss of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, part of the team that found it.

His peers would have had only simple tools such as stone flakes available, so would have found the job of beheading quite difficult. "We think he was already dead when decapitated, and that decapitation was not the cause of death," Strauss says (*PLoS One*, doi.org/7v6).

The oldest evidence before now of decapitation in South America is a skull around 3000 years old, found in Peru. The latest find is a first for the eastern side of the continent: previous evidence of decapitation and human sacrifice came from the west and Central America and is connected with well-known civilisations including the Nazca, the Chimu, the Inca and the Wari.

"This is a skull no one would have expected to find in Brazil," says Strauss.



DANILIO BERNARDO

Mosquitoes can survive without blood meal

GAINS made in the fight against malaria in East Africa could be set back by an invasive plant species, whose nectar could keep mosquitoes alive when blood isn't available.

American invader famine weed, or Santa Maria feverfew (*Parthenium hysterophorus*), is spreading rapidly across East Africa. The weed secretes a poisonous substance known as parthenin, which can cause dermatitis, hay fever and asthma. It is also harmful to livestock.

In recent years it has become

clear that famine weed's flowers are attractive to the female *Anopheles gambiae* mosquito, which spreads malaria.

So Baldwyn Torto at the International Centre of Insect Physiology and Ecology in Nairobi, Kenya, and colleagues took day-old mosquitoes and raised them where they had access to one of three plants: famine weed, the castor oil plant (*Ricinus communis*) or *Bidens pilosa*, a Kenyan vegetable crop plant.

Survival rates after 14 days were about 45 per cent for the castor oil

plant, about 30 per cent for famine weed and little more than 10 per cent for *B. pilosa*. This suggests that if famine weed continues to spread at the cost of *B. pilosa*, mosquitoes may find it slightly easier to survive between blood meals, potentially making the fight against malaria tougher (*PLoS One*, doi.org/7xh).

Torto and colleagues are now trying to find out the impact of parthenin on mosquitoes infected with the malaria parasite. For example, whether nectar from the weed increases biting frequency.

How to fix beating hearts with glue

IT'S amazing what you can do with some party gear. With two balloons, a mirror and a fibre-optic cable you can use a special glue-coated repair patch to shut a hole in a heart – while it's beating.

Last year, researchers created a biodegradable adhesive that solidifies when exposed to ultraviolet light. It can hold biodegradable patches in place to help tissue damage repair itself, and was successfully tested in rats and pigs.

Now, Ellen Roche at Harvard University and her colleagues have developed a tool for delivering the glue-coated patches to internal organs through keyhole incisions.

Their device places the patch onto the wound, then uses two balloons to apply pressure and keep it in place. Finally, a fibre-optic cable shines UV light onto the patch, hardening the glue.

The team used the technique to close a hole between the left and right ventricles of a pig's heart as it was beating.

"It may open up the range of patients who can receive this kind of therapy," says Roche (*Science Translational Medicine*, doi.org/7wb).



WALTER IODOS/IN-SPORTS/ILLUSTRATED/GETTY

Run faster using physics trick

RUNNERS may be doing it all wrong. A slightly different posture could give runners and walkers a gravity-driven boost.

Most runners ignore the concept of angular momentum – essentially momentum associated with rotating, says Svein Otto Kanstad, a physicist and former competitive runner in Volda, Norway. With each footfall, a runner's body pivots on the foot in contact with the ground and rotates forward, driving them towards the finishing line.

But most athletes don't bring the trailing leg forwards quickly enough,

says Kanstad: it is often stretched out behind when the leading leg hits the track, meaning the athlete's centre of mass is tilted backwards and they don't gain much forward movement from the angular momentum. Athletes should learn to pull their trailing leg through sooner, he says (*Proceedings of the Royal Society A*, doi.org/7xc).

Kanstad believes training athletes to run in this fashion would result in a rash of new records. He says retired US sprinter Michael Johnson ran this way: he has held the men's 400 metres world record since 1999.

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Life amid the volcanoes

Bali and Flores

The tour starts in Bali. You'll stop at a rice farm to see the local irrigation system, known as *subak*, before moving on to Mount Batur, an active volcano.

On Flores, the tour will take you to Wolotopo village to watch traditional textile making. You'll stay in an ecolodge, watch the sun rise from the summit of Kelimutu volcano and see its three extraordinary coloured lakes (one pictured, right).

You'll stand on the blue-pebbled beach at Penggajawa and visit one



of the Ngada villages with its steep-roofed, thatched houses. At remote Ranamese lake, you'll have the chance to glimpse the exotic birds, including wild parrots, that live in this forested nature reserve.

SUMATRA

Path of the total solar eclipse on 9 March 2016

JAVA



Here be dragons

Komodo National Park

Varanus komodoensis, the notorious Komodo dragon, is the world's largest living species of lizard, and one of its most fearsome predators. On this stop of our tour, you'll trek to see these giants and view the teeming wildlife that roams the unspoilt islands of the Komodo National Park, a UNESCO World Heritage Site. You'll be staying on a boat – so if you choose, you can swim in the crystal waters, and perhaps see the manta ray colony off Taka Makassar.

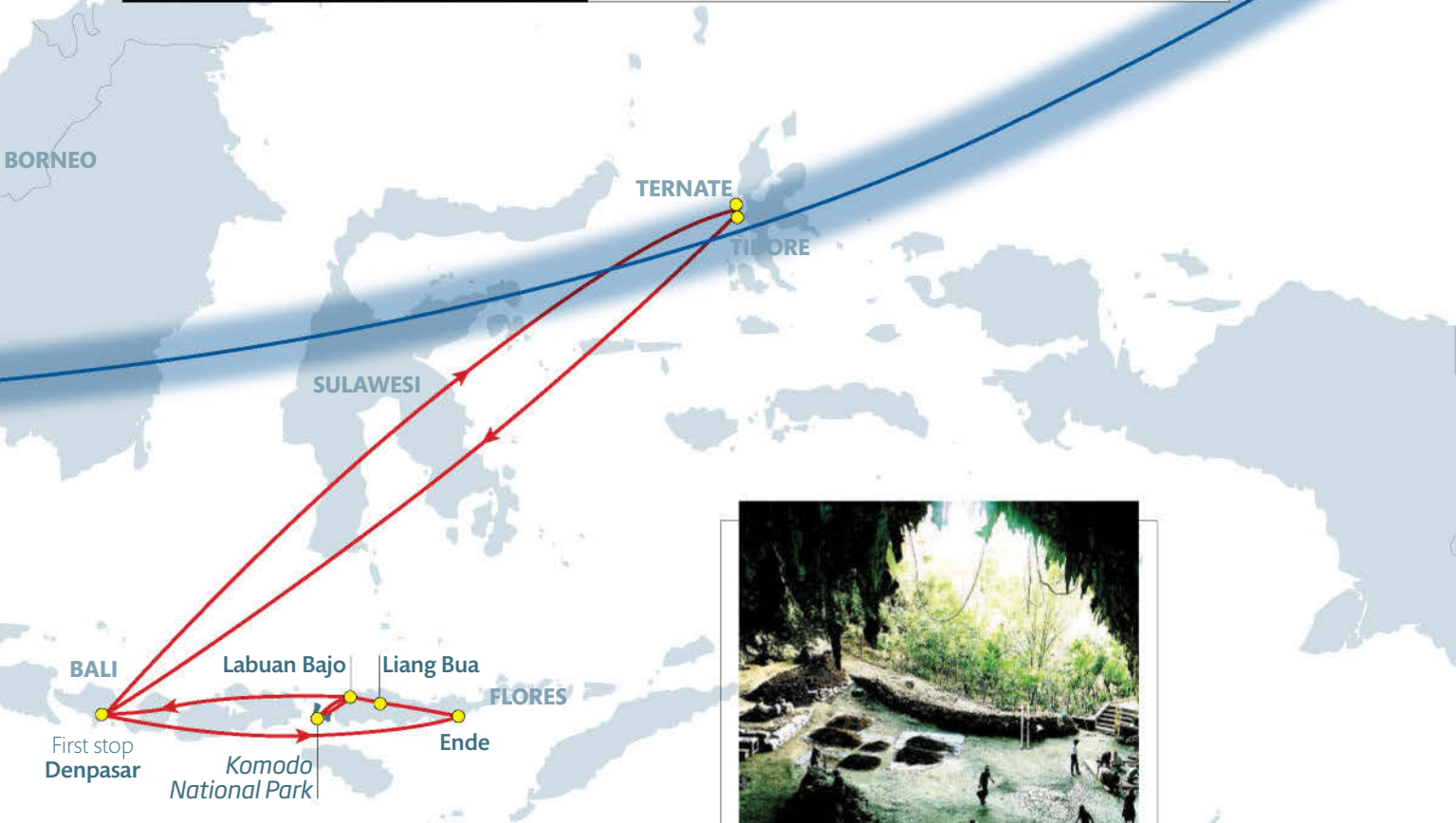


Total solar eclipse

Ternate and Tidore

There is nothing quite like a total solar eclipse. The moon's shadow races towards you at well over a thousand kilometres an hour as the sun's disc is gradually obscured – until just a few final pinpricks of light remain. Then totality is upon you. The world plunges into darkness, the wildlife are baffled, the temperature dips, and, if you're lucky, the magnificent spectacle of the solar corona – the sun's aura of plasma – will blaze across the sky.

The best place to see the 2016 eclipse will be the spice islands of Ternate and Tidore, squarely in the zone of totality. Staying in Ternate city, you will receive a lecture on the eclipse from John Mason, former president of the British Astronomical Association. On the day itself, Intrepid has gained exclusive permission to watch the eclipse from the grounds of the palace of the sultan on the neighbouring island of Tidore.



Home of the 'hobbits'

Liang Bua

A 2003 discovery at an arched limestone cave, called Liang Bua, in western Flores, upturned our ideas about human evolution. It was the partially fossilised remains of a diminutive species of early humans, properly named *Homo floresiensis* but quickly dubbed "hobbits". These creatures lived alongside modern

humans, going extinct only about 12,000 years ago, but they live on in local folklore. On your visit to the cave where the remains were found, you'll learn about how the "hobbit" caused controversy, what we've found out since, and the way its discovery has radically reshaped our ideas of how we evolved.

If you're inspired and would like to know more, please go to newscientist.com/travel/eclipse or call +44 (0)142 059 3015

Quake AI plans disaster rescue

Artificial intelligence can help prioritise rescue efforts in a disaster, says **Chris Baraniuk**

WHEN an earthquake hits, emergency responders need to know which areas to go to first, as quickly as possible.

Can artificial intelligence help? Ahmad Wani thinks so. His start-up, One Concern, has developed technology that, within minutes of a tremor, can predict what areas of a town are likely to be worst affected.

"I think the product is going to save lives," says Ray Mueller, who is on the emergency services council for San Mateo county in California, which sits over the San Andreas fault. "It'll allow you to identify areas that are most

"The real benefit is emergency responders can be very rapidly updated on an emerging situation"

affected by an earthquake so that first responders will know where to go."

To develop the algorithm, One Concern first loaded it with public data including the age, type and construction materials of individual buildings in a town. It was then trained to understand the ways in which earthquakes can damage buildings. By combining this knowledge with seismic data following a quake, Wani says his system can effectively predict how buildings will react to the shock waves.

Once the AI has made its assessment, it plots a damage map that emergency responders can analyse. The streets where buildings are expected to be most devastated are highlighted, and

the map also shows the areas where the highest number of people are likely to be affected.

"We know the population of every block," says Wani. "We multiply the damage and population to get a response priority. So a school with 100 children – it makes more sense to go there."

One Concern's software is currently being trialled by emergency services in San Mateo, who are checking how it handles data from small tremors and what maps it produces. For years there have been concerns over the resilience of housing in at-risk areas along the San Andreas and Hayward faults. The government has a list of 1500 older concrete buildings in Los Angeles, for example, which are believed to be vulnerable.

Two other counties in the region are said to be interested in testing the software. Eventually, says Mueller, responders will also be able to use the system to train their staff by simulating mock quakes and seeing how buildings respond.

DRONE RESPONSE

After a disaster, it pays to find out fast which areas have suffered most damage. Sending out drones fitted with cameras can help, but how do you sift through all the data they bring back?

Patrick Meier, at the Qatar Computing Research Institute, is working with Kathmandu University in Nepal to solve that



DANIEL BEREHLAK/NEW YORK TIMES/REX/VEVINE

Other AI strategies are proving useful in less-developed areas of the world where there is not much data available about the buildings present. Following the earthquake that hit Nepal in April, for example, members of the UK's ORCHID project, an AI research initiative, were involved in trials that ended up changing the actions of response teams on the ground.

In one case, online volunteers were shown satellite images of the affected area after software had pre-scanned them and decided there might be settlements. Volunteers rated images as high

priority if they thought houses were present and the AI engine worked out whether there seemed to be a consensus. Certain sites were then flagged for a closer look by specialist response teams.

Two villages, not previously known to teams on the ground, were identified, and responders were able to provide assistance to the inhabitants.

"AI initially identified a whole batch including those two villages and then humans went through that batch for the cross check," says David Jones, chief executive of Rescue Global, a charity involved with the ORCHID project.

The episode demonstrates how this sort of technology could be best deployed – as a data-crunching tool harnessed by human operators who ultimately call the shots.

"I think the real benefit is if responders can be very rapidly updated on an emerging situation, and AI might be able to do that," says Peter Sammonds of the Institute for Risk and Disaster Reduction at University College London. ■

Painting bot follows your eyes to create art

IT'S no Picasso, but it's a start. A robotic arm that can be controlled with your eyes has just painted its first picture: a simple image of a house, grass and the sun.

Developed by Aldo Faisal of Imperial College London and his team, it extends the human body by providing a third, artificial arm. "It's the first step to human augmentation with additional limbs," says Faisal.

The arm uses an off-the-shelf eye-tracker to follow a person's gaze, sending instructions for movement depending on how and where the painter looks. The commands can move the arm instantly using, for example, fixed gazes and sequences of prolonged blinks. A person can get it to paint a horizontal line by staring at a start point and then an end point.

Sabine Dziemian, a student who provided the eyes for the first creation, says that she didn't need any training. "It feels natural to look where you want to draw," she says.

John Paulin Hansen of the Technical University of Denmark in Lyngby, who is currently developing drones that follow a controller's gaze, thinks such a system is an obvious candidate for operating a robot. "Gaze control will be integrated into phones and tablets within the next couple of years," he says. "It will soon become a part of everyday life."

Sandrine Ceurstemont ■



Do as I look, not as I do

INSIGHT Cyberwar



Hey, wanna cyber?

Firewalls trump fine words

Don't trust a treaty for your cybersecurity, says **Hal Hodson**

THERE are fingerprints everywhere, but no one has been caught. On Wednesday last week, the US Office of Personnel Management (OPM) admitted that the data breach it suffered in June was worse than first thought, with 5.6 million fingerprints among the 21.5 million personal records compromised. It had thought the figure was 1.1 million.

Although guilt is hard to prove, the US government suspects that Chinese hackers stole the biometric data, enabling them to clone the identities of security-cleared personnel.

The attack is part of a string of assaults that has escalated cybersecurity tensions, and US president Barack Obama and Chinese president Xi Jinping discussed the issue this week.

On the table was a treaty that would ban destructive uses of cyberattacks in times of peace. Power stations, airlines and banking infrastructure would all be off limits, bringing cyberwarfare in line with the rules of physical conflict.

But attacks such as the OPM breach are about information extraction rather than destruction of data or infrastructure. That makes them

harder to swear off. So how can the US and China's online relationship simmer down? The current US approach of trying to strong-arm China into a policy that would ban attacks like the one on the OPM won't work, says Jeffrey Carr, CEO of cybersecurity consultancy Taia Global. "You can't bully China into not attacking. They can easily say it's not us and it's very hard to prove that it is," he says.

Instead, the solution is making systems so secure that breaching

"You can't bully China into not attacking. They can easily say it's not us, and it's hard to prove that it is"

them becomes more trouble than it is worth. The other problem with the US approach is that it is treating electronic espionage from China differently to that from the rest of the world.

"The US is trying to create an exception for intellectual property theft that benefits Chinese enterprise," says Carr, when espionage of this sort is rife globally.

Everyone's at it, says Christopher Burgess, a former CIA executive who now runs cybersecurity consultancy

Prevendra. Attributing any kind of attack to a particular organisation is also fiendishly difficult, relying on traditional police fieldwork more than clever software.

In the indictment of Su Bin, a Chinese businessman accused of stealing trade secrets from Boeing last year, an FBI agent describes how the Chinese hacking group he discovered didn't launch any attacks from within China. Instead they set up servers around the world, with remote command and control centres in separate countries. No data went into or out of China on the internet.

The US and China may succeed in signing a treaty that rules out physically harmful cyberattacks in times of peace. But until companies and governments start protecting their computational infrastructure, other kinds of hacking will continue. "If you are looking to make your living by stealing, this is a dream job," says Carr.

And Thomas Rid, a cyberwar researcher at King's College London, says the Edward Snowden leaks have made cyberwar even worse. "Lots of countries think they have to get into this game and get better at it, because look what the Americans can do." ■

'Botivist' calls you to arms

Can social media software trigger real action, asks **Aviva Rutkin**

PUT down your megaphone and pick up your smartphone. A program nicknamed Botivist rallies people to social causes via Twitter.

If you're an activist, spreading your message to like-minded people can be tedious work, says Saiph Savage at West Virginia University in Morgantown. Bots can take those tasks off your plate. "You no longer have to invest time searching for people and trying to get them to do actions for you or with you," she says.

In late April, Savage and her colleagues launched their automated activists into the Twittersphere. There were eight different bots, focused on one issue: corruption in Latin American governments. When Botivist spotted someone tweeting about the subject – perhaps

mentioning "*corrupción*", a bot would send them an inspirational quote or call to action.

The researchers' goal was to see how good the different bots were at convincing people to contribute ideas about tackling corruption.

More than 1000 people were contacted by the bots and 175 replied. Of those, 81 per cent responded to the bots' call to contribute ideas, suggesting that cities get tougher on crime or become more transparent (arxiv.org/abs/1509.06026v1).

Humans could then jump into the discussion with people they already knew were interested in the issue.

Savage and her team are now working on a public version of Botivist. They are also planning another run-through to see how far the bots can move people: can

they convince anyone to show up to an event in the real world?

"One of the biggest benefits of activism is that it can guide citizens to take action," says Savage. "This is taking people that were complaining about corruption, now they're thinking about things they can do to change it."

Savage and her team are not

"People complaining about corruption started thinking about the things they could do to change it"

the first to use bots for what they see as the greater good.

For example, Philip Howard at the University of Washington in Seattle and his colleagues created bots to tweet positive messages about vaccinations, such as links to scientific papers showing their safety.

To their surprise, some of their creations got into arguments with anti-vaccine Twitter accounts that were also run by bots.

"I think if we tried to do an inventory on the public issues that already have bots on them, we'd be surprised," says Howard.

He agrees that bots have the potential to do good, but is wary about encouraging their use, particularly if they are pretending to be humans. "For me it's in the same suite of political tools as negative campaigning or push polling," he says, referring to the marketing technique of trying to sway people's opinions by asking loaded questions in a fake survey.

And bots can be used by anyone. After Russia invaded Ukraine, for example, a brigade of bots appeared on social media, sending out pro-Kremlin messages or attacking accounts that seemed anti-Putin. ■



Front of the line, robot

Why queue for hours to buy the latest iPhone if you can do it by robot? Last week two telepresence robots – just wheels and screens for moving around and video conferencing – stood in line for the new iPhone 6s outside Apple Stores in Sydney, Australia, and Palo Alto, California. Both clung on to their place for their respective human controllers. The Palo Alto robot even paid for its purchase using cash hidden in a compartment behind its screen.

50 bn

The number of internet browsing activity records stored daily by the UK spy agency GCHQ in 2012, according to the latest Edward Snowden files

3D organs start to gel

It may soon be possible to 3D print replacement organs, but first we need to stop delicate tissues collapsing in the process. Researchers at the University of Florida have figured out a way to do it, by printing them right into a thick gel (*Science Advances*, doi.org/7w8). They hope this will let them recreate the fine anatomical structures our organs contain.



Recruited by a person?



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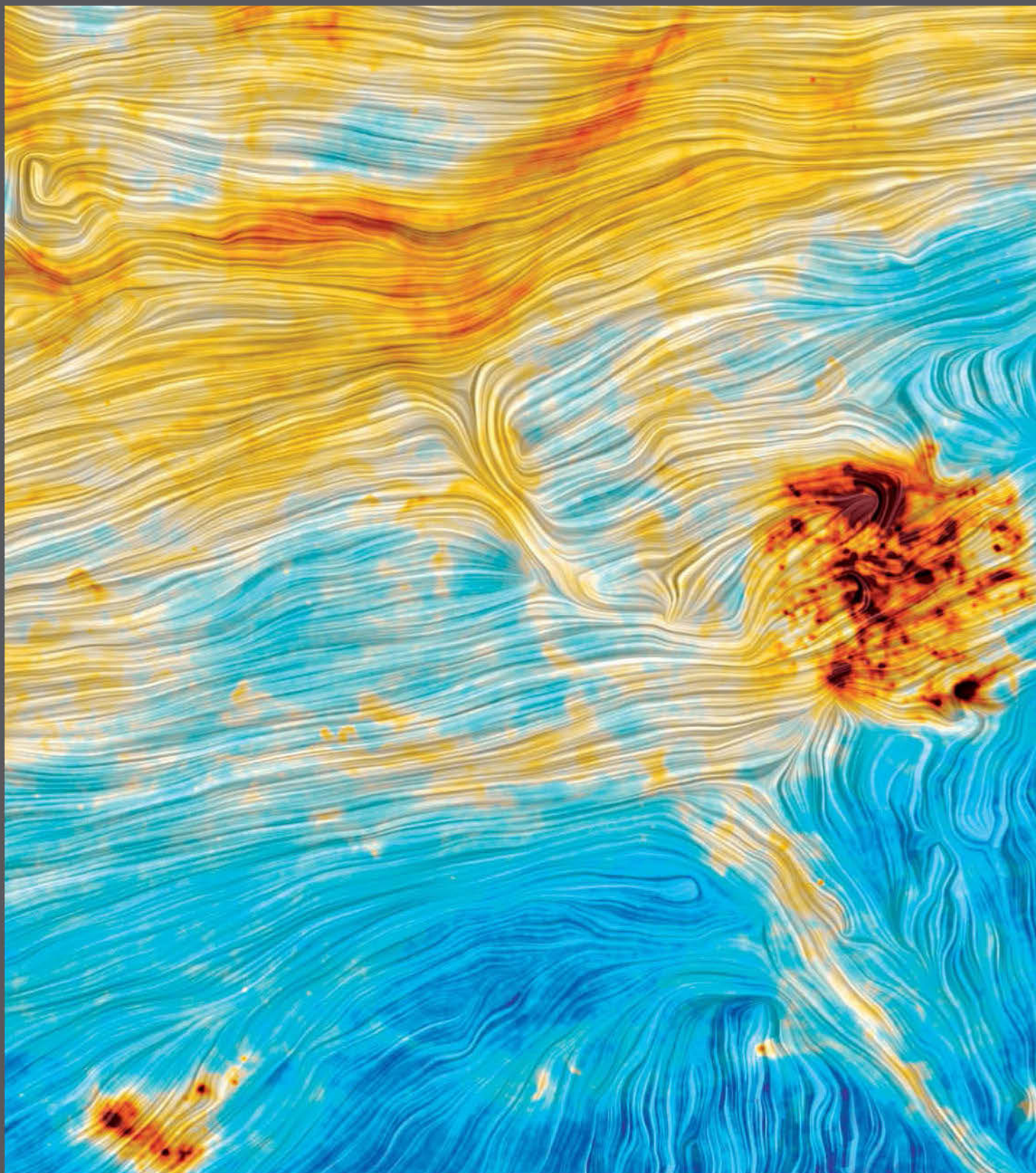
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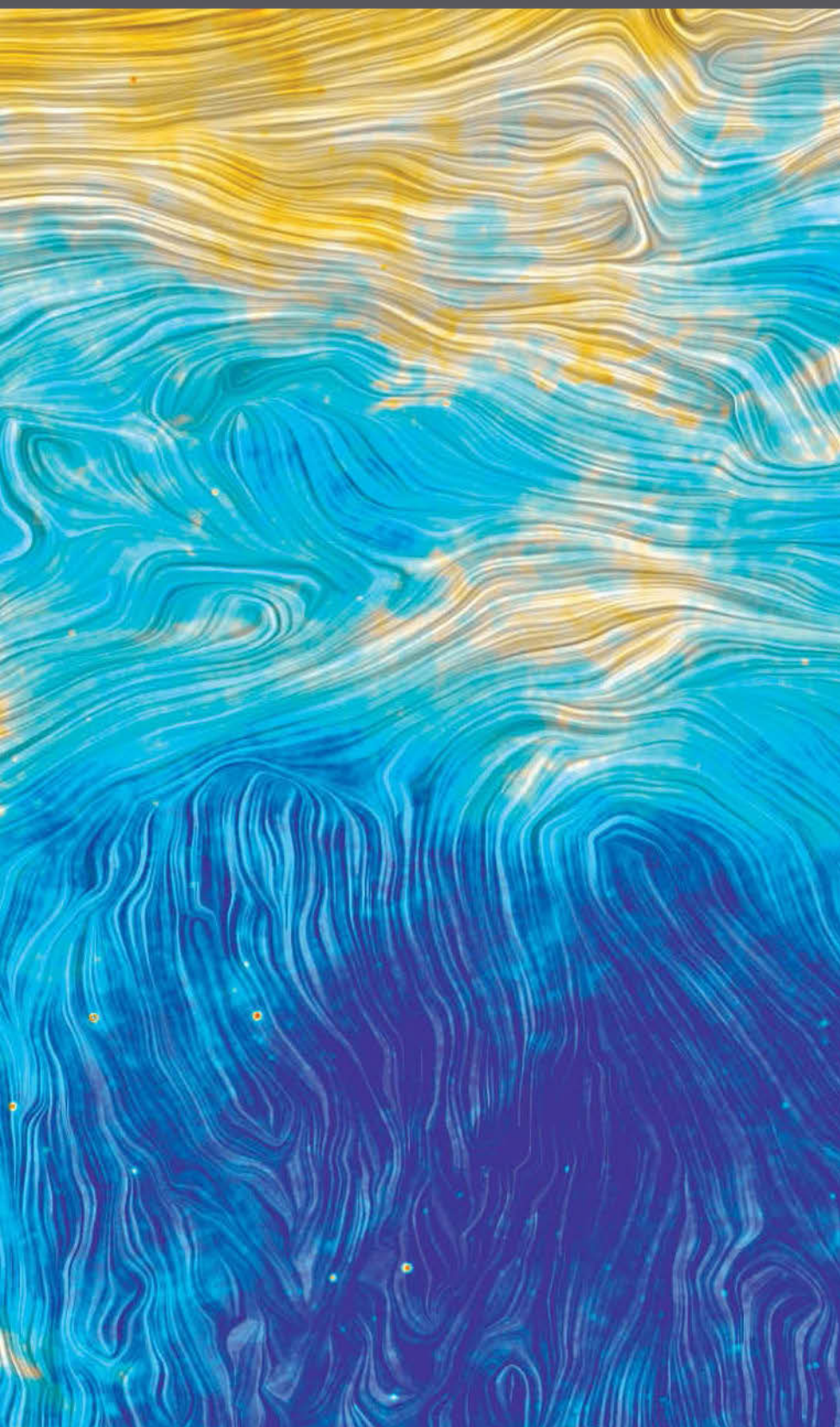
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All of a glow

IT LOOKS like a detail in Van Gogh's famous painting *Cafe Terrace at Night*. But glowing in the centre of this image is the Large Magellanic Cloud - one of our galaxy's nearest neighbours, a mere 160,000 light years from Earth.

With a mass about 10 billion times that of our sun, the cloud is around a hundredth the size of the Milky Way. You can see it unaided in the southern hemisphere as a faint glow between the constellations of Dorado and Mensa.

The Persian astronomer Abd al-Rahman al-Sufi observed the cloud in around AD 964, and then more than 500 years later it was spotted by the explorer Ferdinand Magellan, after whom the cloud is named.

This image was taken by the Planck satellite in an effort to picture the cosmic microwave background - radiation left over from the birth of the universe. It captures dust distribution, with blue being very low dust levels and yellow much higher. The objects Planck picks up close to home, such as the Large Magellanic Cloud, have to be subtracted so the ancient light can be studied.

The orange hues at the top of the image are from the Chameleon, a star-forming complex only 300 light years away from Earth. A dusty filament stretches out from this complex towards the bottom of the picture, aligned with the galaxy's magnetic field, which is represented by the image's texture. Sam Wong

Photography

ESA and the Planck Collaboration

Money for nothing

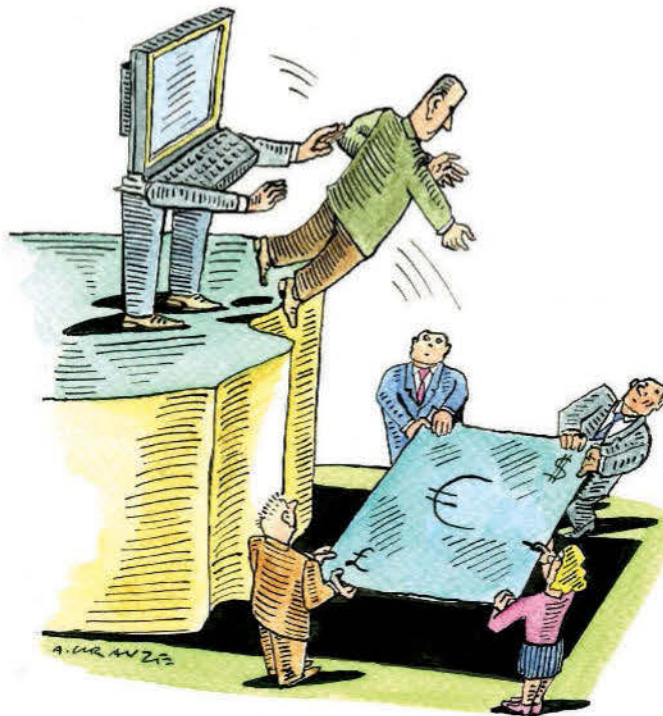
We urgently need to test a universal basic income before a wave of job-killing technology hits, says **Federico Pistono**

THE idea that technology would destroy jobs and dramatically increase unemployment was considered a fallacy not long ago. Economists believed technology always created new opportunities and hence new jobs.

Today, with the rise of machine-learning algorithms and advanced robotics, many have changed their view. It's possible that within 20 years almost half of all jobs will be lost to machines, and nobody really knows how we are going to cope with that.

Those who still have faith in technology's power to create jobs fail to recognise the shift to a "superstar economy", where a handful of companies disrupt markets, make billions and employ very few people, while the rest fight for the scraps.

So how would the millions whose jobs are at high risk of being automated survive in this



landscape? One of the most interesting proposals, that doesn't rely on the fanciful idea that the market will figure it out, is an unconditional basic income (UBI).

It's a simple concept with far-reaching consequences. The state would give a monthly stipend to every citizen, regardless of income or employment status. This would simplify bureaucracy, get rid of outdated and inefficient means-based benefits, and provide support for people to live with dignity and find new meaning.

Perhaps the biggest UBI experiments, involving a whole town in Canada and 20 villages in India, have confounded a key criticism – that it would kill the incentive to work. Not only did people continue working, but they were more likely to start businesses or perform socially beneficial activities compared with controls. In addition, there

The only way is up

A proper living wage could bring major health benefits to societies, says **Laura Smith**

PAYING the lowest earners less than a living wage, all too common in countries including the UK and US, leaves even full-time workers unable to lift their families out of poverty. The resulting harm goes far beyond unpaid bills.

Poverty separates people from resources such as healthcare and safe housing. Those in poverty

experience more wear and tear from stress than the rest of us, and are sicker and die earlier. Their children are more likely to be depressed and to have trouble at school. Their newborns are more likely to die in infancy.

Often, the first response is charitable mental health and medical services. But one of the

best public health interventions would be a living wage.

Poverty's physical and emotional toll is catalysed by the marginalisation of poor people. Social exclusion means they often live outside the scope of therapeutic, vocational, social, civic and cultural resources.

Research indicates that this experience of "outsiderness" hurts because it reduces cognitive and emotional function. It also has a physical dimension: brain

"Every day, low-wage earners do work we need them to do - often work we would not wish to do"

activity associated with social exclusion has been shown to parallel that of bodily pain.

Could raising people's incomes improve their health? Studies say yes. One of the most striking examples looked at the impact of a community-wide income rise when a casino was built on a Cherokee reservation in North Carolina. The study compared psychiatric assessments of children before and after this event. When families moved out of poverty, children's symptom rates began to decline.

By the fourth year out of poverty, the symptom rates were indistinguishable from children

was an increase in general well-being, and no increase in alcohol, drug use or gambling.

These results are promising but not conclusive. We don't know what would happen in other countries, or whether the results would apply on larger scales. New experiments may give a clearer picture. The city of Utrecht in the Netherlands has started a UBI pilot, with a view to extending it to 300,000 residents; Finland is poised to do the same.

But for now, any country implementing a nationwide UBI would be going out on a limb. There are so many variables that if it goes well, it will be difficult to analyse and understand exactly why it worked and how it can be replicated elsewhere. If it goes wrong, it will deter further research and experiments.

It would be better to test it on a random sample of 1000 towns of 10,000 people each than in one country of 10 million. A network of such experiments in many countries is the perfect set-up to learn and prepare for larger-scale projects, right before the wave of automation hits us hard. We need to be ready. ■

Federico Pistono, a computer scientist turned social activist, is author of *Robots Will Steal Your Job, But That's OK*

who had never been poor.

Every day, low-wage earners do the work that we need them to do (and often, that we wouldn't wish to do ourselves). When we allow them to go home with poverty-level wages, we relegate them to the social margins, risking the physical and psychological health of families and communities.

A living wage, on the other hand, means that people who are upholding their end of the social contract never get left on the outside looking in. ■

Laura Smith is associate professor of psychology and education at Teachers College, Columbia University, New York

ONE MINUTE INTERVIEW

Smokers die young, right?

Not always, and people who keep puffing and live long can tell us a lot about the biology of longevity, says **Morgan E. Levine**



PROFILE

Morgan E. Levine researches the genetics of ageing and longevity at the University of California, Los Angeles. Her research paper on long-lived smokers is published in *The Journals of Gerontology* (doi.org/7t6)

What drew you to old-age smokers when investigating the genetic basis of longevity?

There's been quite a bit of animal research suggesting that those who survive the longest are simply better equipped to deal with biological stress. So I started thinking about common stressors humans deal with that might be similar. Smoking is a biologically stressful activity. And its effects on health have been well studied. So if an individual smoked from a young age, and still lived a long, healthy life, their genes seemed like a good place to look for something that made them more resilient.

How old did you have to be to qualify as a long-lived smoker for this study?

We looked at people who were 80 and older. In retrospect, 80 as the cut-off was a bit too young. We would have liked to study people who were even older. But it's hard to find people who live past 80 who smoke. So we looked at people of 80 and older who had started smoking as teenagers or in young adulthood.

How many smokers actually make it that far?

I can't give you an exact figure, but it's a very small proportion. As everybody knows, smoking is related to a whole range of health problems; it is not something that promotes long life in the average person.

But your smokers seem to be immune?

They are much healthier than you would expect; they have pretty good clinical biomarkers and they look a lot like healthy people of the same age who have never smoked. So we think they are a biologically distinct group that have some genetic, and perhaps also epigenetic, factors that allow them to survive, and sometimes even thrive, despite their smoking.

What have they got that the rest of us lack?

It basically comes down to differences in some genes that are involved in a biochemical pathway called the insulin/IGF1 pathway, which has been linked to longevity in a variety of studies. There is good evidence that some variants of these genes help increase cellular maintenance and repair. People who have them, like our smokers, are better able to deal with stress at the cellular level. And that slows the ageing process.

Why do you think we are so compelled by stories about superagers, especially those who engage in bad habits like smoking?

Everyone secretly hopes that they are one of these people. It would make life much easier if you didn't have to exercise every day, eat well and quit smoking. We'd rather not do the work!

But even though everyone knows of someone who lived to 95 while drinking, smoking, and eating fatty foods, they really are the exceptions. The truth is, if you want to have a long and healthy life, you have to have the right lifestyle. Even if you are lucky enough to be one of these individuals, living healthfully will still benefit you. You'll have an even longer, higher quality life. It's not worth playing the genetic lottery.

Interview by Kayt Sukel

Definitely not maybe

Probability is as much use for explaining how the world really works as the flat-Earth theory, says physicist **David Deutsch**

PROBABILITY theory is a quaint little piece of mathematics. It is about sets of non-negative numbers that are attached to actual and possible physical events, that sum to 1 and that obey certain rules. It has numerous practical applications.

So does the flat-Earth theory: for instance, it's an excellent approximation when laying out your garden.

Science abandoned the misconception that Earth extends over an infinite plane, or has edges, millennia ago. Probability insinuated itself into physics relatively recently, yet the idea that the world actually follows probabilistic rules is even more misleading than saying Earth is flat. Terms such as "likely", "probable", "typical" and "random", and statements assigning probabilities to physical events are incapable of saying anything about what actually will happen.

We are so familiar with probability statements that we rarely wonder what "x has a probability of $\frac{1}{2}$ " actually asserts about the world. Most physicists think that it means something like: "If the experiment is repeated infinitely often, half of the time the outcome will be x." Yet no one repeats an experiment infinitely often. And from that statement about an infinite number of outcomes, nothing follows about any finite number of outcomes. You cannot even define probability statements as being about what will happen in the long run. They only say what will *probably* happen in the long run.

The awful secret at the heart of probability theory is that physical events either happen or they don't: there's no such thing in nature as probably happening. Probability statements aren't factual assertions at all.

The theory of probability as a whole is irretrievably "normative": it says what ought to happen in certain circumstances and then presents us with a set of instructions. It is normative because it commands that very

high probabilities, such as "the probability of x is near 1", should be treated almost as if they were "x will happen". But such a normative rule has no place in a scientific theory, especially not in physics. "There was a 99 per cent chance of sunny weather yesterday" does not mean "It was sunny".

It all began quite innocently. Probability and associated ideas such as randomness didn't originally have any deep scientific purpose. They were invented in the 16th and 17th centuries by people who wanted to win money at games of chance.

Gaming the system

To discover the best strategies for playing such games, they modelled them mathematically. True games of chance are driven by chancy physical processes such as throwing dice or shuffling cards. These have to be unpredictable (having no known pattern) yet equitable (not favouring any player over another). The three-card trick, for example, does not qualify: the conjurer deals the cards unpredictably (to the onlooker) but not equitably. A roulette wheel that indicates each of its numbers in turn, meanwhile, behaves equitably but predictably, so equally cannot be used to play a real game of roulette.

Earth was known to be spherical long before physics could explain how that was possible. Similarly, before game theory, mathematics could not yet accommodate an unpredictable, equitable sequence of numbers, so game theorists had to invent mathematical randomness and probability. They analysed games as if the chancy elements were generated by "randomisers": abstract devices generating random sequences, with uniform probability. Such sequences are indeed unpredictable and equitable – but also have other, quite counter-intuitive properties.

For a start, no finite sequence can be truly

PROFILE

David Deutsch researches fundamental aspects of quantum information at the University of Oxford. Find out more about his work on physics and probability at arxiv.org/abs/1508.02048

Probability theory was devised by gamblers hoping to win more money

random. To expect fairly tossed dice to be less likely to come up with a double after a long sequence of doubles is a falsehood known as the gambler's fallacy. But if you know that a finite sequence is equitable – it has an equal number of 1s and 0s, say – then towards the end, knowing what came before does make it easier to predict what must come next.

A second objection is that because classical physics is deterministic, no classical mechanism can generate a truly random sequence. So why did game theory work? Why



was it able to distinguish useful maxims, such as “never draw to an inside straight” in poker, from dangerous ones such as the gambler’s fallacy? And why, later, did it enable true predictions in countless applications, such as Brownian motion, statistical mechanics and evolutionary theory? We would be surprised if the four of spades appeared in the laws of physics. Yet probability, which has the same provenance as the four of spades but is nonsensical physically, seems to have done just that.

The key is that in all of these applications, randomness is a very large sledgehammer used to crack the egg of modelling fair dice, or Brownian jiggling with no particular pattern, or mutations with no intentional design. The conditions that are required to model these situations are awkward to express mathematically, whereas the condition of randomness is easy, given probability theory. It is unphysical and far too strong, but no matter. One can argue that replacing the dice with a mathematical randomiser would not

change the strategy of an ideally rational dice player – but only if the player assumes that pesky normative rule that a very high probability of something happening should be treated as a statement that it will happen.

So the early game theorists never did quite succeed at finding ways of winning at games of chance: they only found ways of probably winning. They connected those with reality by supposing the normative rule that “very probably winning” almost equates to “winning”. But every gambler knows that probably winning alone will not pay the rent. Physically, it can be very unlike actually winning. We must therefore ask what it is about the physical world that nevertheless makes obeying that normative rule rational.

You may have wondered when I mentioned the determinism of classical physics whether quantum theory solves the problem. It does, but not in the way one might expect. Because quantum physics is deterministic too.

“Probability and randomness are large sledgehammers to crack some small eggs”

Indeterminism – what Einstein called “God playing dice” – is an absurdity introduced to deny the implication that quantum theory describes many parallel universes. But it turns out that under deterministic, multi-universe quantum theory, the normative rule follows from ordinary, non-probabilistic normative assumptions such as “if x is preferable to y , and y to z , then x is preferable to z ”.

You could conceive of Earth as being literally flat, as people once did, and that falsehood might never adversely affect you. But it would also be quite capable of destroying our entire species, because it is incompatible with developing technology to avert, say, asteroid strikes. Similarly, conceiving of the world as being literally probabilistic may not prevent you from developing quantum technology. But because the world isn’t probabilistic, it could well prevent you from developing a successor to quantum theory. In particular, constructor theory – the framework that I have advocated for fundamental physics, within which I expect successors to quantum theory to be developed – is deeply incompatible with physical randomness.

It is easy to accept that probability is part of the world, just as it’s easy to imagine Earth as flat when in your garden. But this is no guide to what the world is really like, and what the laws of nature actually are. ■

LUCY RIDGES/MILLENNIUM IMAGES, UK





Am I normal?

Can't concentrate for more than 10 seconds? Forget people's names as soon as you are introduced? Can't stop thinking about sex?

Congratulations – you have a human mind. Our brains are peerlessly creative, but also home to wildly veering trains of thought, strange obsessions, irrational emotions and delusional beliefs.

So what counts as a “normal” mind? Is there even such a thing? Put it another way: are you thinking what I’m thinking?

IS MY MEMORY NORMAL?

I'M NOT a person for a pub quiz team. I can dredge up obscure details from conversations long ago, but I can never remember the heights of the mountains I have climbed or the names of pop bands.

My colleague Richard is the opposite. He's great at remembering facts, but all at sea when it comes to details of his past personal experiences. Should he or I be worried?

Memory is actually mostly about forgetting: all brains discard most of the sensory data they receive. “Tomorrow you'll remember reasonably well a conversation you had today,” says neurobiologist James McGaugh of the University of California, Irvine. “Within a week, a lot of that information will have been lost.” Within a year, the conversation might be gone entirely.

Direct sensory memories only last a few moments. Some go on to make short-term memories, such as the phone number you just dialled. Exact figures are hard to pin down, but an

average brain can probably keep around four things in mind at once, for up to 30 seconds.

Only really important or meaningful information makes it into long-term memory, such as a conversation that contained a personal insult. “We have selectively strong memories for events that are emotionally arousing,” says McGaugh. Long-term memories divide into two main types. Semantic memories record facts, such as the concept of a train. Episodic ones are about events we have experienced, such as a particular train journey.

We probably all know someone who has an encyclopaedic factual memory, but extraordinary episodic memories are a more recent discovery. “These people remember events from years ago the way you and I remember events from last week,” says McGaugh. There's also the opposite condition, in which people struggle to recall even recent events they have experienced. “They know the event happened, but they can't mentally travel back, even one week,” says Daniela Palombo, who researches autobiographical memory at Boston University in Massachusetts.

Most of us fall between these two extremes. True to the stereotype, women tend to have better episodic memories. With semantic memory, men tend to remember spatial information better, whereas women generally perform better at verbal tasks, such as recalling word lists. Personality type seems to be a factor, too: people open to new experiences tend to have better autobiographical memory.

Ageing affects the recall of personal experiences more than that of facts, as does depression. But if by our 40s ➤



we notice we can't remember new names, it's not that our brains are overloaded – our memory capacity is practically unlimited. Rather, gradual changes in brain structure, such as a reduction in the density of dendrites that help to form connections between neurons, make the creation and retrieval of memories less efficient.

But until you start finding it difficult to carry out a simple task you have done many times before, or follow the flow of a conversation, you shouldn't be overly concerned if your memory seems to move in mysterious ways. Ultimately, memory is a personal thing, says psychologist Charles Fernyhough of Durham University in the UK. "People remember things that are important to them. We all have different interests and this changes what our mind processes," he says. "My wife is interested in flowers. When we visit a garden, I just see a jumble of colours, whereas she will remember all sorts of detail."

Memories are systems with multiple parts that change over time, so it is unsurprising that there is a lot of variation. "There are strong individual differences," says McGaugh. "It's a characteristic of human memory that we don't all remember the same kind of things." **Alison George**

IS MY ATTENTION SPAN NORMAL?

For the past few minutes, I have been trying to control the weather with my mind. Thanks to an EEG headband reading my brain's electrical activity, I need only direct my thoughts to a calmer place and the rain will stop, the sun will come out and the birds will sing – at least on my smartphone. But the harder I try, the harder it pours.

The device I am using, called Muse, promises to tame the wandering mind, and so reduce stress and boost focus. Our wandering minds tend to make most of us feel guilty. "We have anecdotal evidence that most people think they mind-wander more than average," says Jonathan Schooler of the University of California, Santa Barbara.

Schooler has attempted to assess "normal" levels of mind-wandering in the lab by, for example, getting people to read extracts of Leo Tolstoy's *War and Peace* and interrupting them to ask their thoughts at random intervals. Such studies reveal we spend anywhere between 15 and 50 per cent of the time with our head in the clouds.

Such a lack of focus might seem terribly inefficient, but probably isn't. "It's unproductive in the context of

whatever you are doing currently," says Schooler. "However, it is potentially productive in the context of whatever it is you're thinking about. You might be reading a book and thinking about planning a party, and it's totally compromising your ability to read the book, but you're making progress on the party." There is good evidence that a wandering mind is an evolved trait that helps us to think about and plan for the future – something that also fosters a uniquely human creativity.

Even so, might there be too much of a good thing? One common worry is that our concentration is dwindling as technology provides more distractions. A recent report published by Microsoft claimed that the average Canadian attention span was down from 12 seconds in 2000 to 8 seconds in 2013 – one second less than a goldfish.

J. Bruce Morton at Western University in London, Canada, is sceptical. For one thing, there's no standard measure of an attention span, he says. "What people want to hear is, how long can you concentrate for? And what should a child's attention span be? But those are not concepts that are normally used amongst scientists studying the topic."

Measuring perhaps the closest thing – the ability to stay focused on



one task, known as selective attention – involves looking at attention shifts on the millisecond scale, such as asking people to state the colour of shapes as they pop up on a screen while ignoring distractions that pop up at the same time. Such experiments show a lot of variation in selective attention. It's low in kids, perhaps because the developing brain has yet to master control over areas that process incoming sensory information. It then improves until the age of 20, when it plateaus until middle age, before diminishing once again.

But there's no evidence technology is making us worse at concentrating, says Morton. Instead, it has just become so well-designed and intuitive that it takes advantage of our innate ability to think of several things at the same time.

If you are still worried, there are things you can do. Stay off the booze – alcohol reduces our awareness of mind-wandering, says Schooler. "When you consume alcohol, you mind-wander more and notice it less." Technologies that promote thought control, like the weather-controlling app, could also help. "People who practice mindfulness mind-wander notably less," says Schooler. **Catherine de Lange**

Read about more oddities of the wandering mind at bit.ly/NSmindwander

ARE MY EMOTIONS NORMAL?

Ever started the day positively and full of determination, only to have someone whip the carpet from beneath your feet with an angry comment? Find yourself easily overwhelmed by hunger, sirens, strong smells or bright lights? Were you a shy or withdrawn child? If you answered yes to some or all of these questions, you may be a "highly sensitive person".

Or do you tend to stay cool, calm and collected, not let other people's emotions influence you and have a strong sense of your own worth? If so, you may chart on the psychopathy scale established in the 1970s by Canadian psychologist Robert Hare.

Highly sensitive, or psychopathic – those are labels that most of us would rather not acquire. But psychologists have devised many scales to assess the

human emotional range, and we are unlikely to get an average score on all of them. According to psychologist Elaine Aron of Stony Brook University in New York, for example, the "highly sensitive" tag accounts for about one in five of us.

Early indications are that a messy mix of thousands of genes determines something like our sensitivity to the environment, says Michael Pluess of Queen Mary University of London – and that's just one factor that determines our emotional make-up. In the past decade, psychologists have identified dozens of genetic variants more common in highly sensitive people that, for example, regulate key hormones such as serotonin, dopamine and oxytocin. Pluess has found that many of these genes increase activity in the amygdala, a brain region involved in processing emotions.

It's not all bad news, however. Although highly sensitive people can often be overwhelmed by negatives, Pluess has found they are also more tuned to subtle positives, are deeper thinkers and are often more creative. Higher sensitivity to external cues may also make them better at adapting to new environments, an evolutionarily advantageous trait. As a general rule, sensitive people also tend to score ➤

"Tend to stay cool, calm and collected? You may well chart on a psychopathy scale"

higher on empathy tests, says Sarah Garfinkel of the University of Sussex in the UK.

Conversely, individuals lacking in empathy or remorse may be desirable when group interests need to be put ahead of individual ones. “These are the people who will fire large numbers of people for the good of the corporation,” says Garfinkel.

The fact that evolution hasn’t selected for any particular combination of genes suggests a mix of people with different character traits is a healthy situation. And while clear outliers do exist – the extreme psychopathy that leads to cold-blooded killing, for example – our emotional reactions are generally kept from running riot by the circuits that connect the prefrontal cortex, the brain’s thinking area, to the amygdala. “That means that in a healthy brain, you can, to some extent, control your emotional reactions with reasoned thought,” says Garfinkel.

Catherine Brahic

Want to know if you are a highly sensitive person? For a more comprehensive list of traits, have a look at Elaine Aron’s questionnaires at www.hsperson.com/test/

ARE MY BELIEFS NORMAL?

Alice laughed. “There’s no use trying,” she said: “one *can’t* believe impossible things.”

“I daresay you haven’t had much practice,” said the Queen. “When I was your age, I always did it for half-an-hour a day. Why, sometimes I’ve believed as many as six impossible things before breakfast.”

In Lewis Carroll’s day, believing impossible things would have been seen as a sign of mental imbalance. Today, we know that it is quite normal. Six before breakfast is probably about par for the course.

Belief is like a personal guidebook to reality: it tells us not just what is factually correct but also right and good. It fundamentally informs our behaviour. It would be nice to think these guidebooks are reliable and dispassionate, but it has become clear that they are not. Beliefs are largely a product of our fallible psychology, gut feeling, the company we keep and biological differences such as how easily we scare (*New Scientist*, 4 April, p 28).



It couldn’t be any other way: if we had to form our beliefs using direct experience and verification, we would struggle to get to grips with even the basics of physical reality.

That isn’t to say anything goes. Well-adjusted adults usually have a fairly stable, internally consistent belief system largely anchored in reality. That still leaves room for contradictions, magical thinking, the supernatural, the paranormal and all manner of other impossible things – not just before breakfast but all day, every day.

Research by Peter Halligan and colleagues at the University of Cardiff, UK, has found that most people hold at least one “delusion-like” belief. These are mild versions of beliefs that could get you diagnosed with a mental illness – that your family have been abducted and replaced by impostors, for example. Most of us seem untroubled by them.

So “normal” belief is a big tent. It is normal to believe unswervingly that God exists. It is also normal to believe unswervingly that (s)he doesn’t. Ditto all the political, social and economic beliefs that we endlessly debate.

It’s hard to argue even that beliefs a given society might deem unacceptable – racism, for example, or apostasy – aren’t “normal” beliefs. Unless you are genuinely deluded, you are probably normal. But then again, delusions feel like real beliefs, so the only way to check that yours are “normal” is to consult a psychiatrist. And believe what they say. **Graham Lawton**

FIVE MODES OF THOUGHT

Since the 1970s, Russell Hurlburt of the University of Nevada, Las Vegas, has been beeping people six times a day to write down their thoughts, and following that up with interviews. His work suggests five basic modes of thinking:

INNER SPEAKING

Hearing words in your own voice

INNER SEEING Seeing a visual image in your mind’s eye

FEELING Any strong emotion

SENSORY AWARENESS

A sensory signal that overwhelms all else. Can be imagined, e.g. thinking of something soft

UNSYMBOLISED THINKING

A concept unattached to any mental words or images

Often, these thought modes are mixed up, as in this example:

“Emma is cleaning up her kitchen... she had picked up a glass from her counter and had noticed two vases of mostly dead flowers... she’s putting the glass upside down into the dishwasher; the seeing the glass and surrounding glasses and the trying to get it to fit are part of her experience... she innerly hears the crunchiness of dead flowers (as if she has picked up some fallen rose petals) [(Imagined) sensory awareness]... Simultaneously she innerly sees the two vases of flowers and the countertop with the dead petals [Inner seeing]. This imaginary seeing is in color and detail... She has a sense that the cleaning up of the flowers can wait; the sense of can wait is somehow present without words or symbols [unsymbolised thinking]”

In this example, is Emma thinking about clearing up the kitchen? Dead flowers? Or nothing in particular? The complexity of such thought processes, and their variation between people, leads Hurlburt to argue that it is almost impossible to assess the content of thoughts, let alone decide their “normality”.

If you accept that these were Emma’s thoughts when the beeper went off and want to categorise them, says Hurlburt, “then you have to throw your hands up and say ‘I can’t do it’”. When science captures thinking it tends to be more big-picture thinking, he says – and that type is fairly rare. “The Emma example is closer to what people actually do, and I don’t think science has fully grasped that.” Caroline Williams



Pleasures of the flesh often pop up unprompted in our thoughts

ARE THE VOICES IN MY HEAD NORMAL?

For Socrates, it came as a warning when he was about to make a mistake. For Sigmund Freud, it was a loved one accompanying him when he travelled alone. Hearing voices has a long history.

And as those distinguished gents perhaps attest, it isn't always a sign of madness: our everyday thoughts often sound pretty voice-like. In 2011, Charles Fernyhough and Simon McCarthy-Jones of Durham University, UK, found that 60 per cent of us experience "inner speech" with a back-and-forth conversational quality.

So where does inner speech end and hearing "outside" voices begin? One answer is that an inner voice "sort of feels like you", says Fernyhough, so you feel more control over it – but given how involuntary many thought processes seem to be, that is rather unsatisfying. "The question is at the heart of the puzzle of hearing voices, and why we haven't got better at understanding it," says Fernyhough.

On the back of their biggest study so far, he and his colleagues estimate that between 5 and 15 per cent of us hear outside voices, even if only fleetingly or occasionally. About 1 per cent of people with no diagnosis of mental illness hear more persistent, recurring voices. Around the same proportion of the population is diagnosed with schizophrenia, challenging the

assumption that the two are related.

So far, there seems to be little difference between the brains of those who haven't been diagnosed with mental illness, but do hear voices, and those who don't hear voices. It's probably best to ask yourself one question before getting worked up about the voices in your head, says Fernyhough: are they bothering you?

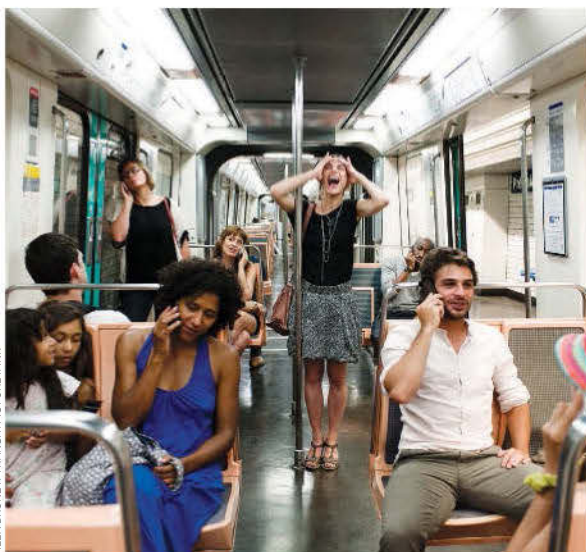
Voices aren't the only expression of our inner thoughts – our minds tell us stories, too. This "confabulation" is a symptom of some memory disorders, whereby people have false recollections. But the rest of us do it too. Experiments show, for instance, that when people are forced to make a random decision they later invent a narrative to explain it.

One theory is that this helps us make sense of a world that bombards us with information, and gives conscious rationale to decisions we make for unconscious reasons. Robert Trivers, an evolutionary biologist at Rutgers University in New Jersey, thinks our lies are more self-serving: by lying to ourselves, we lie better to others too.

This may explain the phenomenon known as positivity bias, whereby people overestimate their virtues. "We put ourselves in the top half of positive distributions," says Trivers. "Eighty per cent of US high school students believe they are in the top half for leadership ability." With these boosting voices, you probably shouldn't be too worried about what you hear – just don't believe everything they tell you, either.

Catherine de Lange

Hearing voices is not necessarily a sign of madness



ALEX BRUNET/TRANSIT/PICTURETANK

ARE MY OBSESSIONS NORMAL?

No one knows where the "men think about sex every 7 seconds" rumour comes from, but it's almost certainly untrue. In 2012, Terri Fisher of Ohio State University in Columbus armed three groups of students with clickers and asked them to click whenever they thought about either sex, food or sleep.

The result: men thought about sex 19 times a day, while women did around 10 times. Food thoughts numbered 18 for men and 14 for women, and sleep 10 for men and 9 for women (*Journal of Sex Research*, vol 49, p 69).

So if those numbers square with your tallies, consider yourself normal (at least benchmarked to students in Ohio). Pleasurable things such as eating, sleep, sex, alcohol, socialising and shopping dominate our common spontaneous thoughts, according to another study by Wilhelm Hofmann, now at the University of Cologne – again of students, this time in Germany.

Darker topics are more problematic. Unless directly confronted by death – a close encounter with a truck or a suspicious lump – most of us almost never think of it. "Terror management theory", developed in the 1980s, even suggests fear of death's inevitability explains our obsession with immediate and pleasurable concerns.

Not everyone is convinced that existential angst underlies quite so much of the human experience. But we do know that around 15 per cent of people have "death anxiety", a morbid obsession that is almost certainly a "non-optimal state of affairs", says psychologist Sheldon Solomon, who co-developed terror management theory. Some research suggests it may underlie conditions such as obsessive compulsive disorder and many phobias including agoraphobia.

But in general, it seems humanity is united in its humdrum obsessions. Russell Hurlburt of the University of Nevada, Las Vegas, has sampled individual trains of thought since the 1970s (see "Five modes of thought", left). "I find very few big thoughts in the sampling studies I do," he says. "I have sampled with some scientists and I don't find very many big thoughts there either." Caroline Williams

THE shiny metal machine would look at home in *Doctor Who's* Tardis. But rather than twisting space and time, it was built to master another elusive entity. The machine is a watt balance and, in simple terms, it weighs energy. Every few weeks, physicist Stephan Schlamminger and his team at the US National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, lift off the lid with a crane and tinker with its insides, adjusting a laser beam here and there, seeking perfect equilibrium. Their goal? To pin down mass.

NIST's watt balance is part of a looming revolution. Along with several other super-precise devices around the world, the machine is helping to usher in a new order in the world of metrology, the science of measurement. It's a world in need of a drastic shake up.

The International System of Units (SI) – the standard that underpins all measurements – is in a bit of a mess. In a bid to do away with out-dated definitions tied to the human world, metrologists are linking units such as the kilogram and ampere to universal constants and exact quantities of fundamental particles.

In doing so, metrologists are bumping up against the limits of our ability to probe the make-up of matter. But success will be worth it. When the revamp comes into play in 2018, the SI will have rigorous foundations for the first time in its history. "It will bring the physical world into sharper focus," says Michael de Podesta, who specialises in temperature measurement at the National Physics Laboratory (NPL) in Teddington, UK.

Shaky foundations

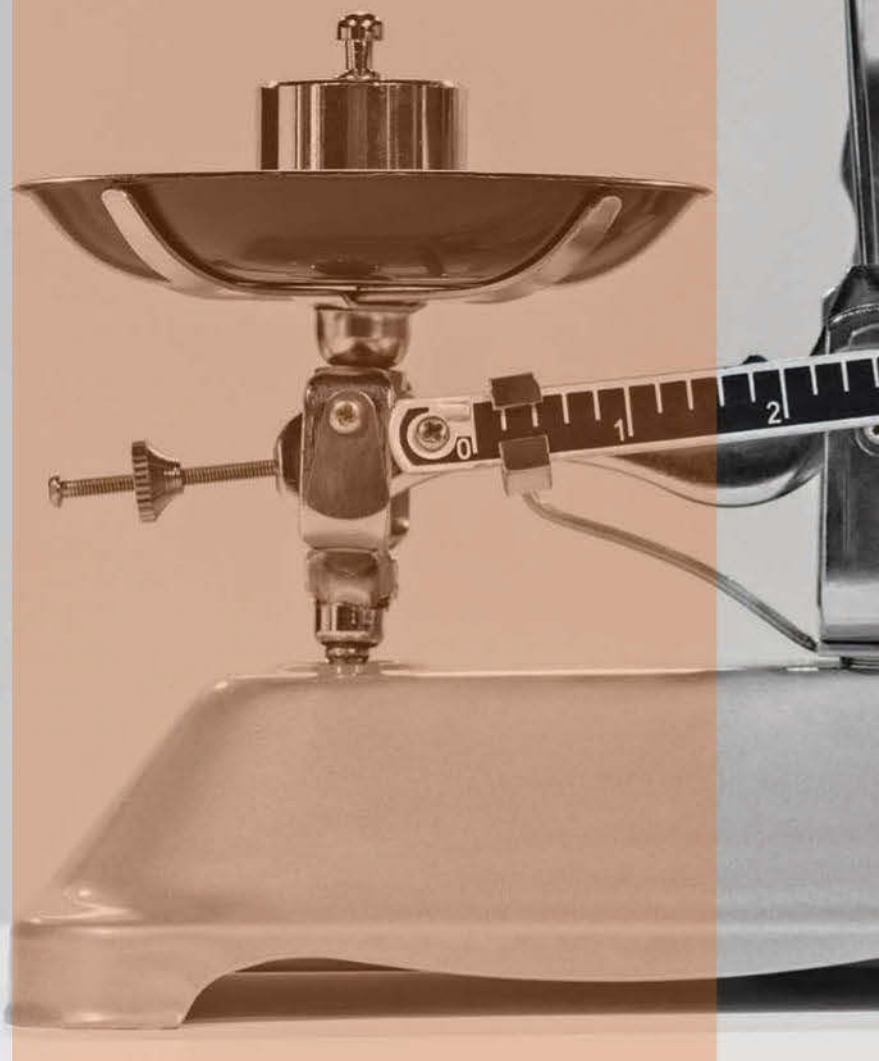
The SI is built on seven "base units", which underpin all others. But its temperature scale is pegged to a particular state of particular water that has to be scooped out of the middle of the ocean. Its unit of current, the ampere, is defined by an impossible experiment (see "Parallel lines", right). Worst of all, its paragon of mass is a lump of platinum alloy that is constantly changing. And according to the SI, when the one true kilogram changes, so does our measurement of the mass of every particle in the universe. "Metrology is the foundation of all science," says Schlamminger. "If you have broken foundations that is no good."

Units of measurement need to be the same for everyone, everywhere. "The point about the SI is it should be universal – whether you are doing particle physics in CERN or buying vegetables on the high street," says Jonathan Williams, a colleague of de Podesta's at NPL, who works on electrical standards. ➤

THE MEASURE OF THINGS

Redefining the units that mark out reality is taking us to extremes.

Stephen Battersby reports





VLADIMIR GOONIK/GETTY

PARALLEL LINES

The ampere, the SI unit of electric current, currently has the most awkward definition of all: "The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length." But that's an impossible measurement to make.

Fortunately, the new definition simply requires the counting of electrons. The new amp will be equal to 1.6×10^{19} electrons passing per second. Counting them can be done with an electron pump, a microscopic device that can hold a single electron and control its motion by changing the voltages on a set of electrodes. "It's like a lock on a canal," says Jonathan Williams at the UK National Physics Laboratory (NPL) in Teddington. "But in the electron pump, the gates open and close a billion times a second."

The other difference with a canal lock is that at the quantum level, an electron pump is subject to "blurring". An electron can suddenly pop up outside the lock in a process called quantum tunnelling. This introduces some uncertainty in the process, but it is being reduced. "We are trying to get them to behave like classical balls - to be in a particular place with a high probability for a certain time," says Stephen Giblin, who works on the NPL's electron pump.

Until recently, the NPL had the world's best results in electron counting. But that record is now with a group at the German National Metrology Institute in Berlin, who counted out a current with an uncertainty of only 0.2 parts per million.

RECALIBRATING REALITY

Only three of the seven SI base units – the fundamental set from which all other standard units are derived – are defined directly in terms of fundamentals of nature

NO CHANGE



TIME: SECOND

Tied to the rate of radioactive decay of the caesium-133 atom



DISTANCE: METRE

Tied to the speed of light in a vacuum



LUMINOUS INTENSITY: CANDELA

Tied to the frequency of a visible light source (unlike other SI units, the candela depends on human physiology)

CHANGE DUE



MASS: KILOGRAM

Currently defined in terms of a lump of platinum alloy in Paris, France. The new definition will tie it to an exact numerical value known as the Planck constant



TEMPERATURE: KELVIN

Currently defined in terms of the triple point of a sample of purified seawater (see main copy). The new definition will tie it to an exact numerical value known as the Boltzmann constant



ELECTRIC CURRENT: AMPERE

Currently defined in terms of the force produced between parallel wires of infinite length. The new definition will tie it to the charge of the proton



AMOUNT OF A SUBSTANCE: MOLE

Currently defined in terms of the number of atoms in 12 grams of carbon-12. The new definition will break the link with the kilogram and tie the mole to an exact numerical value known as the Avogadro constant

But defining measurements is a thorny problem. Take the kilogram. The existing international prototype kilogram (IPK) is a cylinder of platinum-iridium alloy that was cast and polished to size in the 1870s as one of a set of about 40. Some of the copies are kept with the IPK in the International Bureau of Weights and Measures in Paris, France. Others are owned by standards laboratories around the world, and all are occasionally compared with one another. In 1949, metrologists found that the IPK and its companions had drifted apart by about 50 micrograms. Oops.

Endangered species

Every time the IPK is handled, there is a danger of introducing a new error. “You are afraid to touch it,” says de Podesta. Then there’s the small matter of the goats. In 1879 it was specified that the IPK was only to be cleaned with a chamois leather. Now, 150 years on, the chamois goat is an endangered species. “Getting hold of chamois leather is a problem,” says de Podesta.

What to do? Metrologist Ian Mills at the University of Reading in the UK served as president of the SI consultative committee for units for 17 years until 2014. “For the whole of my time we were worrying about how to define the kilogram,” he says. Thankfully, a solution is on the horizon – one that doesn’t involve goats.

When it comes to redefining the kilogram, one option is to set it as a certain number of particular atoms. This is the aim of the international Avogadro Project. Its researchers have polished two 1-kilogram spheres of silicon-28 to exquisite precision – they claim they are the roundest objects in the world – which allows them to take extremely precise measurements of the diameter. In turn, this lets them calculate the spheres’ density, and thus the precise number of atoms within, thanks to the uniform nature of silicon’s crystalline structure.

Another option is to define the kilogram in terms of the Planck constant, as physicists Barry Taylor and Peter Mohr of NIST suggested in 1999. This number, written as h , is the constant of the quantum world. It relates the energy of any particle to its frequency of vibration: energy is h times frequency. And because energy is related to mass, so is h . It’s rather circuitous. But on the other hand, the Planck constant is a more fundamental aspect of reality than the mass of an atom.

In 2011, the Planck proposal won. The next step is to measure the Planck constant in

terms of our existing kilogram. To do that, physicists have turned to the watt balance.

The machine has a weight on one side and an electromagnet on the other, and it balances gravitational forces (that is, weight) against electrical forces (that is, energy). So far, so simple. Where it gets fiddly is measuring the electrical force. To measure the voltage in the electromagnet, physicists use the Josephson effect: a superconducting flow of electrons oscillates at a frequency that is intimately linked to the voltage. Then, to measure the electromagnet’s resistance, they use the quantum Hall effect: sudden quantum jumps in resistance when a thin-film conductor is put in a strong magnetic field.

It’s hardly intuitive. There seems to be no easy way to say how the watt balance gives a kilogram in terms of h without delving into the quantum details. “We’ve been puzzling about it, but we don’t have an answer,” says Mills.

The good news is that it provides very accurate measurements. The best yet is by the Canadian National Research Council in Ottawa. With a machine originally built at NPL, researchers there narrowed down the uncertainty of h to less than 20 parts in a billion. Now NIST is aiming to beat this with its new balance – as are teams in France, Switzerland, New Zealand and South Korea.

And it turns out that there is a role for the Avogadro Project’s silicon spheres as well. The mass of a silicon atom can be compared with the mass of an electron using a device called a mass spectrometer. In turn, the mass of the electron can be linked to the energy of light emitted by atoms – again as a multiple of h . So you can also build a Planck kilogram by counting silicon atoms.

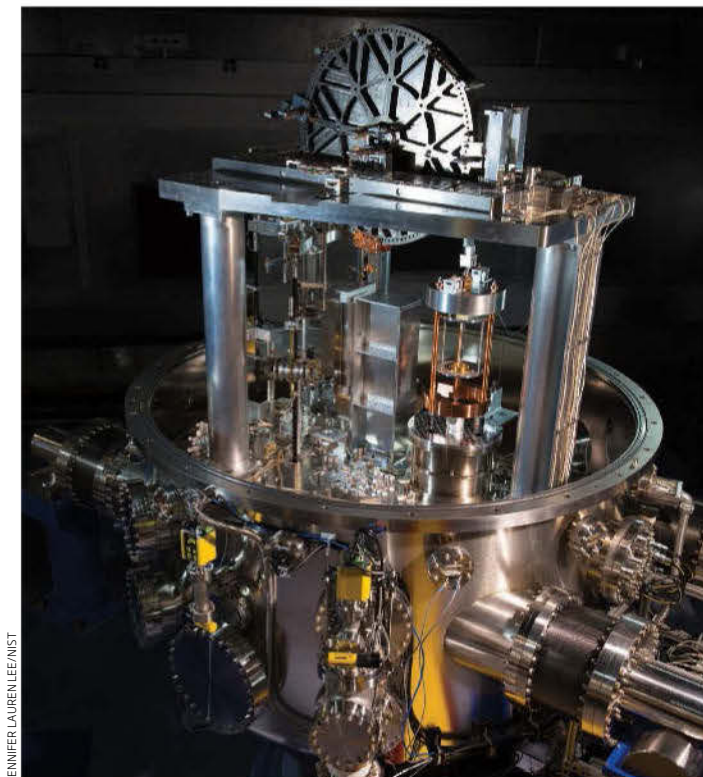
For many years, results from the two approaches disagreed. Researchers with

“The unit of current, the ampere, is defined by an impossible experiment”

the Avogadro Project guessed that it might be to do with impurities in their spheres, so they started again from scratch.

First, silicon-28 was isolated at the Central Design Bureau for Machine Building in St Petersburg, Russia. Then, at the German National Metrology Institute (PTB) in Berlin, this was turned into a single crystal, which was cut up and polished into two almost perfect spheres at the Australian Center for Precision Optics in Lindfield, New South Wales. Back at PTB, scientists used lasers to measure the

Around the world,
watt balances are
bearing down on mass



JENNIFER LAUREN LEE/NIST

diameter of the sphere in all directions, analysed the remaining impurities and fired in X-rays to find the spacing between atoms.

In 2011, the group found that their atom-counting method agreed with the watt balance – with experimental uncertainties of only 30 parts in a billion. Last year, after discovering a hint of metallic contamination in the surface and etching it off, they got that down to 20 parts per billion. “The watt balance comes out of physics, the Avogadro Project from chemistry,” says Schlamminger. “That the two agree so closely is very powerful.”

The Avogadro Project is now stepping up a gear: researchers are preparing two spheres of even purer silicon-28, with four more on order. As well as mechanical polishing, the PTB team will use a beam of ions to make the surfaces even smoother. “We will be able to remove all the mountains,” says Horst Bettin, head of the Avogadro group at PTB. The biggest of these mountains are 100 nanometres high. The new spheres should have peaks of no more than 5 to 10 nm.

If all goes to plan, these results will define the new kilogram. What’s more, they will also be used to redefine the mole – another base unit – by tying it to the Avogadro constant.

That leaves the kelvin. One kelvin, the SI unit of temperature, is currently defined as $1/273.16$ of 0.01°C – the temperature of the triple point of pure water, at which ice, liquid and vapour can coexist. In other words, 0.01°C is 273.16 kelvin. But like the kilogram and its chamois leather, it all hangs on something surprisingly arbitrary. In 2005, the definition

was updated to specify how to obtain pure water: you take a boat to the middle of the ocean, scoop a sample from the surface and distil it. “This is what happens when you have a unit that isn’t abstract,” says de Podesta.

So the kelvin will soon leave water behind and evolve into an entity of pure energy. Temperature is a measure of how fast the particles in an object are moving around – how much kinetic energy they have – and the two are linked by the Boltzmann constant, which is about 1.38×10^{-23} joules per kelvin. This allows the kelvin to be defined as an unchanging fraction of a joule. And a joule is derived from the kilogram, metre and second. With those pegged to constants, the kelvin will be too.

But it all hangs on knowing the precise value of the Boltzmann constant. To measure it,

HOW LONG IS A PIECE OF STRING?

Many units of measurement were once tied to quantities that varied between individuals

1 CUBIT

the distance from a person’s elbow to the tip of their middle finger

1 GORUTA

the distance that a cow’s call can be heard

1 CAROB SEED

a unit for measuring gem stones, which gave rise to the modern carat

1 OXGANG

the amount of land that could be ploughed using one ox in a single season

de Podesta’s team have used a singing wisp of gas: measuring the speed of sound in argon at the triple point of water gives you Boltzmann’s constant. In 2013, they thought they had this number down to less than one part per million – good enough for the new definition.

The wrong argon

Then they hit a snag. To do the calculation you need to know the average mass of the atoms. On Earth, most argon is in the form of argon-40, with a trace of argon-36. The team had diligently compared the balance of these isotopes in their sample against what they thought was the balance in the atmosphere. “But it turns out people disagree about the isotope ratio in the atmosphere,” says de Podesta. So now they are redoing the experiment using pure isotopes. These are insanely expensive, he says. Argon-36 is £4000 per gram. “You open a valve at the wrong time and – *pff* – it’s gone.” The expense has paid off, however. “I think we’ve made the most accurate temperature measurements in human history,” says de Podesta.

With everything set to meet the long-held goal of nailing all our units of measurement to nature, will that be the end of the metrology business? Hardly. For a start, you can’t weigh out a kilogram of apples with just a definition. So there will still be standard kilogram lumps sent out to industry – but they will now be calibrated against watt balances and silicon spheres. And PTB is working on a plan to make much cheaper standard spheres out of natural unpurified silicon, then comparing their density with the pure silicon spheres simply by weighing the two in and out of water, as Archimedes is said to have done to test the purity of a golden crown. Similar kit will need to be developed for the other units.

And we can’t rule out the definitions changing again. We have chosen what seem to be the most accessible constants today, says Williams. “In 100 years, there might be different ones.” He also says that within a decade, the second may be pegged to a new generation of atomic clocks, more accurate than today’s caesium-based ones.

We are marking out reality with more precision than ever before. What will there be to show for it? “It is like having work done on the foundations of a house,” says de Podesta. “It’s time consuming and expensive and in the end the house looks the same. But you have confidence that it will not subside.” ■

Stephen Battersby is a consultant for *New Scientist*



Pumpkins, fiery leaves and other icons of autumn are on climate change's hit list, finds Fred Pearce

The fall of fall



JOHN KEATS described a “season of mists and mellow fruitfulness”. Nat King Cole sang of “autumn leaves of red and gold”. But what if the leaves cease to turn red and gold, and the mellow fruits don’t cling on until the arrival of autumn mists?

Howard Neufeld of Appalachian State University in Boone, North Carolina, is one researcher who thinks this may be so. He says the curtain may be descending on one of the season’s defining spectacles, the fiery spread that sweeps through the forests of New England each fall – and climate change is to blame. “Warmer falls reduce the intensity of the red colours – of sugar maples especially, the mainstay of colour in the north-east of the US,” he says. It’s all down to how warmer autumn nights tweak the internal chemistry of leaves: they cause sugar levels to drop, which in turn affects the pigments responsible for those signature reds. Sadly, russet tones are not the only autumn tradition at risk, although amid the losers there could be surprise winners as well.

Autumn is the poor relation of spring in terms of academic interest. Amanda Gallinat of Boston University calls it “the neglected season in climate change research”. In the UK, a long amateur tradition of observing the start of spring has produced detailed records that go back to the 18th century. But, according to Kate Lewthwaite, citizen science manager at the UK’s Woodland Trust, the systematic recording of autumn’s timeline only started in 2000.

“Spring captures the imagination of naturalists more than autumn events,” says ecologist Ally Phillimore at the University of Edinburgh in the UK. “And the onset of autumn is less obvious.” The first flower in bloom, the first swallow or cuckoo call, the first insect’s buzz, the first squirrel out of hibernation all grab our attention, whereas the last berry or buzz or birdsong will probably pass unnoticed. Gallinat and others are rapidly filling in our knowledge gaps, but for now we still know a lot more about how climate change is affecting spring.

As winters shorten and the air warms up earlier in the year, spring is starting sooner in the midlatitudes. But whereas some species are shifting their schedules to adapt to changing temperatures, others respond to fixed cues – such as day length – with the result that parts of the ecosystem become

out of sync with each other. Plants, for instance, may produce tender shoots before the animals that feast on them arrive.

At the other end of the calendar, you might think that warmer, longer autumns would simply keep the lethal cold of winter at bay. Not so. Researchers are finding that a disrupted autumn is at least as problematic for wildlife as a disrupted spring. Here too, the normal chain of events is being thrown sharply out of sync.

Spectacles at risk

Warmer autumns may disrupt leaf displays in more ways than one. Instead of today’s synchronised cacophony of colour, different tree species could change colour at different times, says Neufeld. And in the case of New England, some trees could disappear altogether. Sugar maples, yellow birch, red spruce and others are likely to shift north into Canada, replaced by less colourful oaks. This is already happening: the US Forest Service reports that two-thirds of the tree species in the region are heading north.

All of this could be a big problem for a tourist industry worth \$25 billion a year. And the spectacle may be at risk elsewhere too. Japanese autumn now comes more than a week later than in the mid-20th century, according to Keiko Masuda of Ryukoku University in Kyoto, Japan. Leaves on maples around the city’s temples often drop to the ground before they turn red, in part because warmer temperatures are drying them out. A similar fate could await the golden hues of aspens in the Rocky mountains and larches in the Alps.

Back in New England, staff at the non-profit conservation body Manomet, based in Plymouth, Massachusetts, have been catching and releasing birds each spring and autumn since 1969, taking note of their size and the timing of their migration. Gallinat is part of the team that has been analysing these records. She says that many birds – particularly those preparing for short migrations, such as the junco sparrow – are taking advantage of the good weather to start their journeys up to a week later than they did a few decades ago. But others, especially those heading for the tropics, leave earlier.

In the UK, Tim Sparks of Coventry University is a leading light in a nationwide project ➤

“Earlier ripening poses problems for songbirds that rely on berries late into autumn”

launched by the government’s Centre for Ecology and Hydrology to plug gaps in our knowledge of the changing seasons. He says the same mixed pattern is emerging in Europe as in the US. Many birds that breed in the UK are now arriving earlier in the spring and flying away again sooner: after all, what is there to keep them in the country after their brood has hatched? But the behaviour isn’t universal. “Multi-brood species such as swallows may get in another brood, and end up leaving later,” says Sparks.

To untangle all of this, ecologists must determine what cues different species use to time their migration, hibernation or leaf fall. The patterns may be complicated.

Studies at the Harvard Forest in Petersham, Massachusetts, which has been under continuous observation for more than a century, suggest that some tree species have a fixed amount of time “in leaf”. “An early spring budding is correlated with an earlier leaf fall, irrespective of the weather,” says ecologist John O’Keefe of Harvard University.

Whether because of their biological clock or summer warmth, fruit trees and bushes are also changing habits. In many parts of the northern hemisphere, fruits are ripening earlier than before. Humans may enjoy bumper harvests, but the shift is a growing problem for birds and mammals that rely on berries for food late into the autumn. Gallinat says that this is particularly true for many New England songbirds, which have been delaying their migrations in warmer years but are finding that the native blueberries and huckleberries on which they normally feed don’t last to the end of the longer season. There is no luxury in a long Indian summer if your larder is bare. Vulnerable birds include the hermit thrush and the blackpoll warbler, a tiny songbird with a particular need to be well fed because it flies from New England to the South America without pausing to land.

Alien feast

Luckily, there is another option for late departers. Gallinat says they are seeking out other sources of food, including berries from invasive trees and bushes that are thriving in New England’s warming climate. These aliens almost all produce fruit for longer than the native species. “When walking in the forests of New England, you see the invasive oriental bittersweet and others with still-green leaves when native species have [already] lost theirs,” says her colleague Richard Primack. “They fruit later than native species, and warblers and thrushes are feeding on them.” Alien species generally get a bad press from ecologists, but in this instance appear to be more lifesavers than ecological terrorists.

Warmer autumns probably help the invaders to prosper, and in more ways than one. Gallinat notes that by filling a new ecological niche and sustaining late-migrating birds, invasive plants gain an advantage: the grateful birds preferentially excrete their seeds across the landscape. Could the invasive fruit trees be nature’s way of adapting to climate change? “That is an interesting question,” says Gallinat. “It is certainly possible they will help bird species adapt by providing a late-autumn food source as native fruit availability declines.”

There are other signs of a new order settling in. In the Arctic, the spring snowmelt is coming ever earlier, but instead of breeding earlier, Arctic ground squirrels are taking a breather. Because global warming is also



JAMES ROSS/MILLENNIUM IMAGES, UK

A SEASON OF SNIFFS

Never mind the demise of red leaves and pumpkins (see main story), some autumnal changes could literally get up your nose.

A study earlier this year by Lynda Hamaoui-Laguel at the Laboratory of Climate and Environmental Sciences in Gif-sur-Yvette, France, forecasts a dramatic lengthening of the European hay-fever season. By mid-century, she found, it could stretch long into the autumn owing to the spread of ragweed – an invasive species from North America to which many people are allergic.

Just as troubling is the prediction that many disease-carrying insects will buzz on for longer, breeding several more generations as the year progresses, says plant ecologist Amanda Gallinat of Boston University. The results are likely to range from plagues of Scottish midges biting their way into October and November to a growing prevalence across the northern hemisphere of mosquito and tick-borne diseases, such as dengue fever, Lyme disease and West Nile virus.

The timing of bird migrations

could be an aggravating factor. Birds are a prime target for bloodsucking insects such as mosquitoes. If birds head out on their migrations while it is still warm enough for mosquitoes to flourish, the insects will need other sources of blood.

Mammals, including humans, already get bitten more in late autumn after migrating birds depart, says Gallinat. That is why human infections of West Nile virus are much more prevalent in the autumn. A longer, warmer season will only worsen the situation.



JONATHAN BERCH/NARRATIVES/PIAUFPICTURE

Sad but true:
Jack-o'-lanterns
can't take the heat



FREDERIC LARSON/SAN FRANCISCO CHRONICLE/POLARIS/EVERETT

delaying the autumn chill, it makes sense for them to wait for warm conditions to settle in properly before they breed, safe in the knowledge that there will be enough time for their young to fatten up for the winter. Michael Sheriff of Pennsylvania State University in University Park has observed this pattern in Alaska. Longer springs, summers and autumns mean that conditions are much less harsh for the young than they once were, and many more survive.

This again suggests that the potential for some species to adapt to a changing climate is greater than was thought. The Intergovernmental Panel on Climate Change has predicted that up to one-third of species could die out in a warmer world as climate zones shift. If species are more adaptable, that could be an overestimate. Delayed autumns ought also to mean longer growing seasons, more photosynthesis and so more carbon dioxide sucked from the atmosphere and locked away into plants. That could be a welcome negative feedback on climate change.

Not so fast, says Shilong Piao of the Laboratory of Climate and Environmental Sciences in Gif-sur-Yvette, France. Warmer autumns will also boost soil respiration, which releases CO₂ to the atmosphere as all that extra plant matter decays. So both photosynthesis and respiration should get a boost in warmer autumns.

For now, respiration has the edge. Piao reached this conclusion after examining records of the annual cycle of CO₂ levels in the atmosphere, sometimes known as the Keeling curve after Charles Keeling, who began logging CO₂ in 1958. The curve shows more CO₂ in the air during the northern hemisphere's winter as dying vegetation switches to respiration, and less in summer after photosynthesis resumes. Over the past 25 years, Piao has found that the winter CO₂ build-up has been happening earlier. Luckily, says Piao, for now the autumn trend is more than made up for by a more vigorous photosynthesis during warmer springs. We must hope that continues. "If future autumn warming occurs at a faster

rate than in the spring, the ability of northern ecosystems to sequester carbon may be diminished," warns Piao.

A shifting autumn will, of course, change agriculture round the world. Much of the time, farmers will simply change their practices in response. But along the way, some of the flavours and traditions of autumn could be lost: pumpkins, for instance. Warm temperatures are a boon to pumpkin crops but hot temperatures make them go bust as the plants shut their flowers for the much of the day, keeping pollinators out. High temperatures in the late US summer and early autumn have already been partly blamed for a ruined pumpkin crop in 2013. And 2014 was the hottest UK Halloween on record, with temperatures on the last day of October exceeding 20 °C. As trick-or-treaters sweltered, the country suffered a dreadful pumpkin

harvest. This most seasonal of crops could fall foul of climate change.

Even Bonfire Night, which heralds lengthening nights in the UK, is changing. Sparks remembers 5 November as the day British gardeners would pack up for the year, content that their gardens were dead for the winter. "In my childhood in the 1960s, my father burned all the leaves and garden rubbish on Bonfire Night. There was nothing left to fall from the trees." But nowadays, horse chestnut leaves around his home obscure the view of the firework displays.

Bear in mind, however, that although change may unsettle human traditions, and perhaps provide new annoyances (see "A season of sniffs", opposite), it is not necessarily bad for nature. Species find ways to adapt. Maybe there will be new leaf colours in the fall. Maybe weeds and trees moving north will keep hard-pressed birds and insects in food where the natives falter. Maybe invasive species will continue to find new roles, feeding migratory birds. The old mellifluous synchronies may be dead. But we must hope there will be new ones. ■

Fred Pearce is a consultant for *New Scientist*

THE MONARCHS' REPRIEVE

Autumn may be changing (see main story), but we should not be too nostalgic. Take heart in the unexpected winners – such as the monarch butterflies that famously migrate from the US Midwest to winter roosts in central Mexico. The sight of millions of migrating butterflies arriving to drape themselves over trees is a true wonder of nature.

But the migration has declined by 90 per cent since 1990. Last year, alarmed ecological institutions petitioned the US government to give the monarchs new protection under

the US Endangered Species Act. They blame the monarchs' spectacular demise on the widespread use of glyphosate, a herbicide they say is wiping out milkweed plants across the Midwest. Monarchs lay their larvae exclusively on milkweed.

However, David Wagner of the University of Connecticut in Storrs thinks warmer autumns may come to the plant's rescue by nudging it north into non-agricultural lands in Canada and the northern US states. "This will almost certainly increase the habitat and breeding success of monarch butterflies," he says.

TO YOUR CAMERAS!

How is autumn changing near you? Share your pictures with us on Twitter, Facebook and Instagram using #FallOfFall

The stuff of life

When it comes to water, good science can act as both a tool and a weapon in the hands of ordinary people, finds **Fred Pearce**

A River Runs Again: India's natural world in crisis, from the barren cliffs of Rajasthan to the farmlands of Karnataka by Meera Subramanian, Public Affairs, \$26.99

The Last Drop: The politics of water by Mike Gonzalez and Marianella Yanes, Pluto Press, £14.99

Connecting the Drops: A citizens' guide to protecting water resources by Karen Schneller-McDonald, Cornell University Press, \$24.95

THE Arvari river in India's Rajasthan desert had been dry for decades. The fields along its banks were parched, the people were leaving. Then a local youth, Kanhaiya Lal Gurjar, began recruiting village women to dig small dams – johads – in the seasonal streams that once fed the river. The dams held back the monsoon rains, which percolated underground. Local wells began to return to life and, as if by magic, the river itself returned.

This simple story of local environmental intervention is the centrepiece of *A River Runs Again*, US journalist Meera Subramanian's ode to her native

India, to its natural world and those who want to protect the country from breakneck industrialisation under its premier, Narendra Modi.

Although its narrative is lyrical and heartfelt, the book is also an ode to science – good science that respects natural processes rather than seeking to subjugate them. The johads that revived the Arvari river are one element in a nationwide movement that is turning its back on Western water technologies like large dams, and focusing on traditional Indian practices, such as catching the rain locally and keeping it on

"Villagers know more about local water conservation than most engineers, but no one seeks their views"

the land. It is working: across Rajasthan, 12,000 johads and similar structures bring water to fields and communities left high and dry by big engineering.

Subramanian, whose fluid writing has appeared in everything from the journal

Nature to *The Wall Street Journal*, shows a rare gift in her ability to combine personal but uncontrived field reporting with the cultural sensitivity of a returning daughter of India and the critical faculties of someone confident in the science.

When she reminds us that "the villagers have better knowledge about water conservation in their areas than most engineers, but the present system never seeks their views and government officers dismiss them as illiterates", these words ring true because they describe the local knowledge, the hydrology and the politics with equal skill.

She never lets the romantic trump realism. Harvesting rainfall in Rajasthan ticks many boxes for her, bringing local control over water to people previously reliant on government canals and tankers. But she knows that downstream dams have sometimes suffered when water is held back. "There is only so much water to be caught, after all."

Subramanian is open to being surprised by her interviewees. On one occasion, she discovers that many rural Indian women enjoy the apparently arduous journey out of their villages to collect firewood and water each morning. It is the one time that they are free of the men.

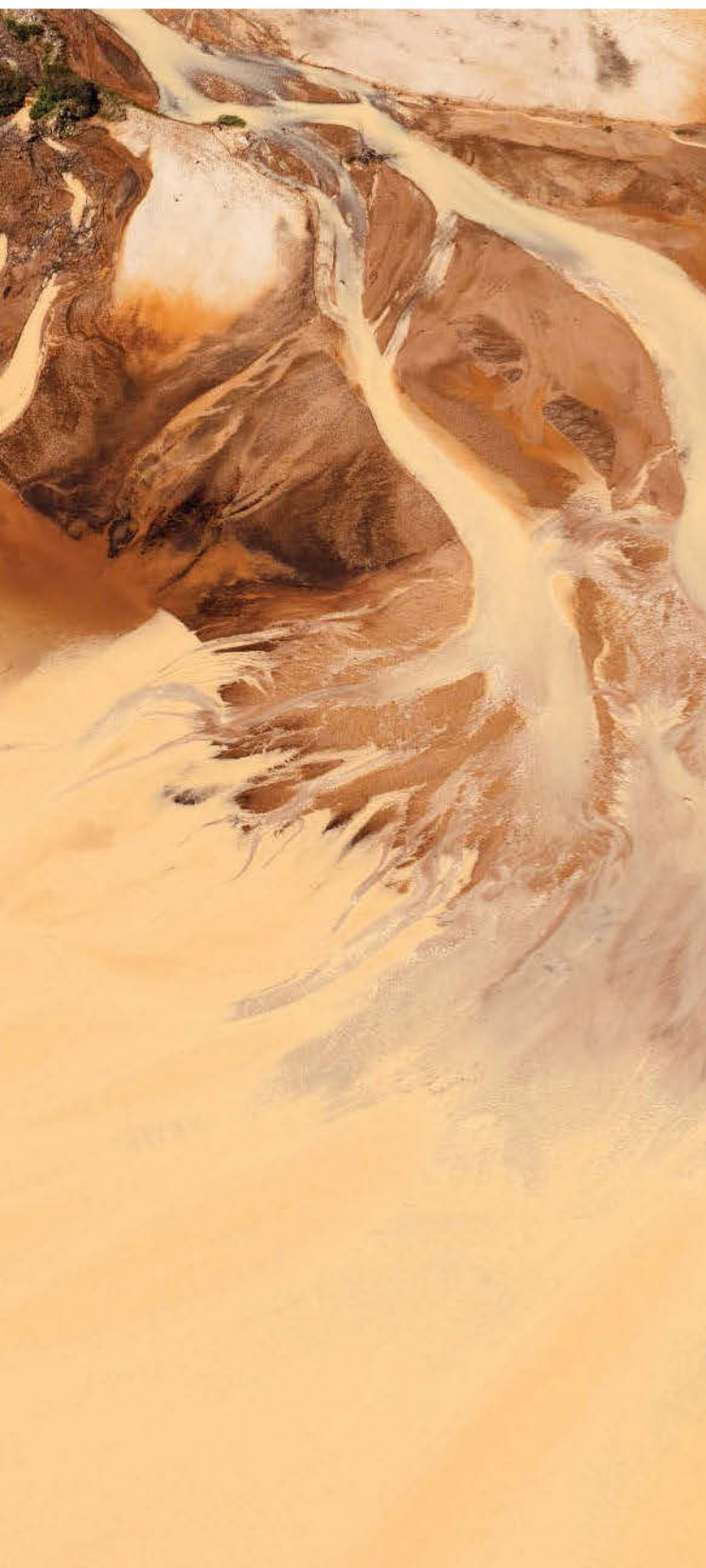
In five essays, painstakingly researched in long journeys to find "the small, the local, the indigenous at work across India", Subramanian roams far beyond the issue of water. She explores the battle between organic farmers and proponents of intensive farming. Who can best feed a fast-growing population



DIETER TELEMAN/PAFOS



PETE MCBRIDE/NGS



Stirring the waters: in the US, water from mining run-off can pollute (left), and fracking gathers protests (right); daily wash in India (far left)

containing more undernourished people than any other nation? She interviews dozens of Indian women in their kitchens and exposes the scandal of how “clean” cooking stoves were mis-sold to billions of the world’s poorest people.

Her feminist politics shine through in her analysis of the power play behind India’s assault on population growth in places like Bihar, which she dubs “a dismal place to be a woman”. And her skills as a nature reporter combine with her love and knowledge of raptors in illuminating the strange story of India’s vanishing vultures.

Subramanian’s heart is in rural India and the continuing relevance of its traditions. She yearns for a future in which small remains beautiful. “India, home of the god of small things, is the perfect place for the model of the micro to emerge,” she says. But her optimism and idealism are rooted in rigour, science and a humanistic approach that drives her stories of day-to-day life across that country. This is reporting of the highest standard.

Sadly, *The Last Drop* is rather different. It is not, as the subtitle suggests, about “the politics of water”. Instead, it is a political template imposed on water.

Mike Gonzalez, a Trotskyite professor and biographer of Hugo Chavez, and his co-author, Venezuelan journalist Marianella Yanes, seem interested only in critiquing capitalism by blaming the “commodification” of water and the privatisation of its supply for the ills of an industry that – rather confounding their argument – is still largely in public hands.

Their thesis is not helped by factual inaccuracies. For example, in the space of two pages, the authors state that the Nile rises



FRANCES M. ROBERTS/PHOTOSHOT

in Sudan, and that millions have been poisoned by arsenic in water along the Indus river, rather than the Ganges. There is a good book to be written about the collision between globalisation and water as a public “good”. But this ill-informed rant is not it.

After the high idealism of Subramanian and the low politics of Gonzalez, Karen Schneller-McDonald’s *Connecting the Drops* feels like a cold shower of American realism. This “citizens’ guide to protecting water resources” explains, in terms that suburbanites can grasp, why their local streams, ponds and wetlands matter, and how to defeat housing developers or fracking engineers who want to drain, pollute, culvert or cover them over.

The author provides this kind of advice for a living in New York’s Hudson Valley, where she is an environmental consultant working with community groups. Much of what she offers is specific to the US, but her style is inclusive. And her advice on how to call out officials, politicians and corporations who insist their decisions cannot be contested because they are “based on science” is of universal value. Science, she knows, is a tool and a weapon, but rarely a policy. ■

Fred Pearce is a consultant for *New Scientist*

Staying alive

Capturing NASA's mindset is key to *The Martian's* success

The Martian directed by Ridley Scott:
On release from 30 September

By Simon Ings

TOWARDS the end of Ridley Scott's *The Martian*, marooned NASA astronaut Mark Watney (played by Matt Damon) says goodbye to the habitat that has kept him alive for more than 500 days. As he enters the airlock to leave, he pauses, turns — and there, on a table, is his space helmet. Sourly, he snatches it up: he has nearly gone and killed himself again.

Set about 30 years in the future, *The Martian* tells the story of how Watney survives at the very cusp of death, at which every trivial error, every moment of forgetfulness, will kill him in about 35 seconds. Jeopardy is the stuff of adventure movies. What makes all this different is its remarkable lack of interest in what jeopardy feels like “inside”, and its loving depiction of how people should deal with it.

The film is based on a story by Andy Weir, a software engineer and self-confessed geek who ignored traditional publishers in favour of a blog through which he could work out technical solutions to Watney's problems. Watney has been left for dead on Mars without enough food and water to survive until the next mission — due in four years' time. But there is much more to it than that.

Before he shot his last scene at the Korda Filmpark, outside Budapest in Hungary, CultureLab caught up with Damon, who was tasked with conveying what it would be like to survive for 18 months only on potatoes grown

in your own faeces. He explained: “Ridley and I agreed *The Martian* is not one of those existential survival movies. Neither is it just a popcorn kind of whizz-bang, he's-never-really-in-danger type of experience. The key is to have the audience feel the enormity without it seeming ponderous. And it has to be funny, because Watney and his colleagues are capable of doing really dangerous things and having a good sense of humour about them.”

No wonder NASA got behind the film: its tale of the administration's daring, unsanctioned bid to rescue one of their own gives every department a hero. But where *The Martian* gets interesting is in its refusal to take heroism at face value. Watney survives because he is smart and knowledgeable, can get by without company and likes the sound of his own voice; and because coming up with a strong, snarky one-liner can make his

whole day. He survives because, as he says in a message meant for his parents, “I love what I do and I'm really good at it.”

This distillation of NASA's philosophy is endorsed by Ellen Ochoa, director of the Johnson Space Center in Houston, Texas, who praised Weir's book for encapsulating aspects of mission training. “It is a very realistic

“The key is to have the audience feel the enormity of the stakes without it seeming ponderous”

scenario of what we go through when we train crew members and flight controllers, who must quickly analyse a situation and prioritise tasks,” she said. She added that resilience is “probably the single most important characteristic to have as an explorer, and Watney proves to be extraordinarily resilient”.

The film's whole approach

favours accuracy over visual bombast. Less spectacular than Alfonso Cuarón's *Gravity* (2013), and a lot less silly than Christopher Nolan's *Interstellar* (2014), *The Martian* has exploited NASA's enthusiasm well, conjuring up habitats, spacesuits, spacecraft and launch vehicles that carry its stamp of approval.

Is *The Martian* a nerd thriller? For sure: you can't have Damon declaring he will “have to science the shit out of this” and not find yourself moving your biro to your shirt pocket. But it's more than a love letter to science. It is an entertaining depiction of a way of behaving that keeps people alive in extreme circumstances: love your job; embrace the little you can do and do it; like it or not, death is always coming, so to hell with it. This, more than any amount of Mars-mission razz, is the real heart of *The Martian*, the source of its optimism, and a quality deserving of praise. ■



Watney survives on Mars because he likes his own company

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The deadline to apply for this position is November 2, 2015. Please direct questions to Lauren Nakashima (lnakashima@berkeley.edu).

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Speak Now or Forever Lose Your Science

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The rarefied world of academic science may be what drew many researchers to the scientific endeavor, but remaining isolated from the populace could harm their chosen profession and undermine progress in science and technology.

By all estimates, the public's understanding of science – from basic principles like the scientific process to complicated concepts like string theory – is poor at best. An extreme example of this pervasive problem is Sarah Palin's mockery of fruit fly research during the 2008 campaign trail. In a speech on autism, Palin stated that she and then running mate John McCain would nix projects that “really don't make a whole lot of sense” and have “little or nothing to do with the public good... things like fruit fly research in Paris, France.” Little did she know that studies on *Drosophila* fruit flies have yielded a number of insights into autism and other illnesses, and in fact underpin the whole of modern genetics.

Palin might have an ineffectual grasp of science and technology, or she may be pandering to constituents who feel little connection to science. The average Joe doesn't necessarily appreciate the value of model organisms or the years of research and development that go into making a single drug, two aspects of the scientific endeavor that most researchers take as universal truths. And why should they? Too often scientists are reticent to leave their sphere of learning and investigation to engage the general public, choosing only to speak out when awakened to the goings-on of the outside world by statements like Palin's or the threat of cuts in federal funding.

No time to be silent

The issues faced by today's researcher amount to more than just mere insults and threats. According to an analysis by the American Association for the Advancement of Science (AAAS), federal spending on

research and development plummeted by 16.3 percent from 2010 to 2013. Support for R&D hasn't dropped that fast since the end of the space race in the 1970s. With continued blows like sequestration and government shutdowns, many scientists are spending more time writing and rewriting grants than they are doing the research itself. A popular bumper sticker circulating in San Diego area reads “A 10% payroll isn't funding. It is a lottery.”

The outlook is bleakest for the youngest scientists, many of whom are reconsidering their choice of profession or looking at opportunities outside the United States. In 1980, close to 18 percent of the scientists holding a coveted NIH-funded RO1 grant were age 36 and under. As the pie of NIH funding has continued to shrink, that number has fallen to about 3 percent. While the U.S. investment in science has flat-lined, other countries have upped their commitment. For example, the Beijing Genomics Institute, only one of many such facilities in China, has more capacity to sequence human genomes than all of the genome centers in the United States combined. As the director of the National Institutes of Health (NIH) Francis Collins noted, funding cuts have left scientists demoralized.

“We're losing what we've already invested in and funding fewer grants,” said Collins, speaking at Research!America's 2013 National Health Research Forum. “Which of those would have been the next breakthrough in cancer? Which of those would win the Nobel Prize in another twenty years? We'll never know. To sit here and say this is just how politics works is not okay. We are undertaking a noble enterprise that can make a difference in the health of ourselves and our families. We should be making a lot of noise.”

However, trying to insert science into politics can be like trying to mix oil with water. The two disciplines are so incompatible, says John Hardin, Executive Director of the North Carolina Board of Science and Technology, because they take completely different approaches to the way they explain or react to the world. For example, scientists investigating climate change might compile the data and try to figure out if it is happening, and to what extent. Politicians, on the other hand, care less about what the science says and more about what the public thinks about the issue. Science is supposed to be objective and free of values. Politics is authoritative and driven by values. But with the right effort, there can be middle ground.

To read the complete article provided to New Scientist by Burroughs Wellcome Fund visit:

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EDITOR'S PICK



Give victims, not murderers, fame

From Darryl Bagley

I want to thank Sally Adee for not mentioning the name of the killer in her report "What to do when murder goes viral" (5 September, p 10). It frustrates me that the murderers always get fame and the victims are usually doomed to become a forgotten statistic.

In the case of the murder of Alison Parker and Adam Ward, I know the victims' names, but cannot remember the killer's name; and that's the way it should be. Sadly it's usually not the case.

Take for example, the tragedy of the Sandy Hook school shooting in Newtown, Connecticut on 14 December 2012. I'm sure many remember the name of the killer: how many of us remember the names of the innocent children he killed, or the heroic teachers who gave their lives to protect the children in their care? I'll admit I don't remember them. Here's hoping other media follow your lead, so the murderers become the forgotten statistic and the victims are the ones we'll never forget. Camberley, Surrey, UK

The editor writes:

■ It was a fairly easy decision in this case: but we wouldn't be surprised if, in future cases, ethical reporting required naming perpetrators. Self-publicity through social media will pose new challenges for the media, including *New Scientist*.

Saturated fat is not off the hook

From Neal Barnard,
Physicians Committee for
Responsible Medicine

You report a new Canadian study on the risks of trans fats and saturated fat (15 August, p 6). This meta-analysis of 41 previous reports looked at the data in two ways. One way revealed the dangers of saturated fat, while the other did not. Neither showed that saturated fat is safe.

The first analysis used more or less raw data, finding that people whose diets were heaviest in saturated fat had a 12 per cent higher risk of developing heart disease and a 20 per cent higher risk of dying from it, compared with those whose diets were lowest in saturated fat. Trans fats, found in many snack foods, were also linked to heart disease.

The second looked at data adjusted for cholesterol levels, body weight, and so on. This is statistically risky. For example, saturated fat increases cholesterol levels, which, in turn, increase cardiovascular risk. Adjusting the data for cholesterol levels as if they were an independent variable can make the link between saturated fat and cardiovascular risk disappear.

Meta-analyses are like metal detectors. If they find a landmine, you can be confident that it is there. But if they don't find one, that does not mean that it's time to go skipping through the field. It may be that your method is simply not sensitive enough. Washington DC, US

Vegetables taste better with flaws

From Beck Lowe

Marta Zaraska's article on making fruit and veg less bitter neglected an important aspect of reduced nutrition (1 August, p 26). Plants

produce various phytochemicals in response to pest attack. The practice of selling only perfect-looking produce necessitates zero tolerance for pest damage. Home-grown fruit and vegetables, complete with blemishes, taste more complex than store-bought produce and, I suspect, offer a wider range of phytochemicals and thus nutrients.

Heathcote, Victoria, Australia

Climate change as a conflict trigger

From Meg Slatcher

Debora MacKenzie's article on welcoming refugees concludes with the comment that "climate triggered the crisis in Syria..." and says that more climate refugees are coming (12 September, p 10).

I would like to know more. Does she mean climate change? Have climate changes been so obvious in Syria? I thought that much of the trouble in the Middle East could be attributed, at least in part, to water wars but I would be interested in an article that laid out the climate changes that triggered the war in Syria. Sheffield, UK

The editor writes:

■ It would have been more precise to say that a long drought, which researchers link to climate change (7 March, p 6), made many Syrians destitute; that is thought to have triggered the 2011 wave of protests that triggered the current crisis.

Safety and three-parent babies

From Anna Dyer

I read with interest Justin Havird's proposal that sex evolved because of mismatches between DNA in mitochondria and cell nuclei (19 September, p 28). It brought to mind a report on mitochondrial substitution as a new treatment

for women unable to carry a pregnancy to term due to faulty mitochondria (4 June 2014, p 28).

If Havird is correct in his hypothesis then shouldn't we question the use of enucleated donor eggs, carrying a second woman's mitochondrial DNA, until we know more? Will these mismatches be a significant disadvantage to the resultant offspring? At least, should we not ensure that the "nuclear" and "mitochondrial" mothers are genetically related to each other?

I feel that this issue should be reviewed in the UK by the Human Fertilisation and Embryology Authority in the very near future. Fareham, Hampshire, UK

A chain of citation going nowhere

From Simon Fairlie

Fred Pearce's pursuit of the origin of the statistic that invasive species have contributed to 40 per cent of recent extinctions (5 September, p 26) reminded me of my own investigation into another commonly repeated factoid: that 100,000 litres of water are required to produce 1 kilo of beef. After tracing the statistic back through a similar series of academic iterations, it emerged that it takes into account every scrap of precipitation that falls upon the land that a beef cow occupies – even though rain would fall whether the cow were there or not.

Charmouth, Dorset, UK

Octopuses, take aim and throw...

From Michael Legge

I was delighted to read about gloomy octopuses throwing things (29 August, p 14). Over 40 years ago, diving in Canada's Georgia Strait, I happened upon an octopus in a rock crevice. It

f “Anyone else really want to go buy one of these now? I’d love a car that can cheat tests!”

George Lees isn’t taking the revelations about Volkswagen’s emissions software (26 September, p 21) as seriously as some

bombarded me with abalone shells. The aim was excellent: they all bounced off my face mask.

Many whom I told thought I was confabulating. Now, thanks to you, my credibility is restored. *Victoria, British Columbia, Canada*

Happiness with and without children

From Clare McEwen

As a mum of a 3-year-old boy, I was fascinated to read the article about parenting and happiness (5 September, p 40). I hadn’t stopped to consider whether I was more happy, less happy, or much the same since the birth of my son. Happiness is a tricky thing to define and even trickier to measure, with so many potential intricacies that I doubt it can be accurately assessed.

Parents, unlike non-parents, can remember what it was like before children. So we may think about things we gave up, things that we cannot do so easily now and, after a tough day, this may seem a little depressing. Those

without children, generally, don’t know what they are missing, and are happier with their lot. I don’t think I am any less happy, and I would not be without the joys of being a mum, but my perception of happiness has changed. *Banbury, Oxfordshire, UK*

Suspicious over trust for sale

From Annemieke Wigmore

Is a “trust hormone” pill really a good idea (29 August, p 14)? With the effect of enhancing “cooperation response”? I can easily think of a few more, or even less, authoritarian regimes who might agree with you. *Cudworth, Somerset, UK*

Sowing confusion about bees

From Bill Summers

Beekeepers are not surprised that the current moratorium on neonicotinoid insecticides in the

European Union has actually increased the oilseed rape yield this year in the UK (15 August, p 24). Farmers have become lazily addicted to chemicals in the mistaken belief that having no insects is better than having any, even pollinators.

There is a case to be made that the “open field trials” carried out by the crop protection industry underestimate the negative effects of pesticides on pollinators in the real world. An open field area treated with neonicotinoids may be as little as 2 hectares: bees, if not contained, will range over 3000 Ha. Work at the National Agriculture Research Centre in Islamabad in 2007-2008 compared oilseed rape yields of plants in cages with honeybees compared with those in cages without them. Honeybees increased yield by 80 per cent.

Only banning neonicotinoids will ensure that the benefits of restraint will accrue to all. The moratorium on their use in the EU should be made permanent, not lifted as has happened in Suffolk as an “emergency” measure. *Sturminster Newton, Dorset, UK*

The causes of the Tianjin explosion

From Peter Urben, Brethericks Handbook of Reactive Chemical Hazards

Your report on the explosion at Tianjin in China mentions that “ammonium and potassium nitrate... would have exploded” (22 August, p 6). But potassium nitrate is neither explosive nor flammable, though it can intensify adjacent fires by decomposing to give oxygen. Ammonium nitrate is seriously explosive, though extensive pre-heating is usually needed.

Acetylene is explosive, yielding twice the energy per unit weight of TNT – though it will not do so unless compressed. And, more importantly in this context, it forms a very wide range of explosive mixes with air.

And as long-time critics of smoking should know, cyanide is a common component of fumes from charred nitrogenous materials. Nor is it that rare in the environment – I have a cyanide-manufacturing plant in my backyard (the laurel *Prunus laurocerasus*). And it will be cyanide, not specifically the sodium salt, which has been looked for, and found, in water. *Kenilworth, Gloucestershire, UK*

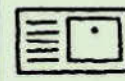
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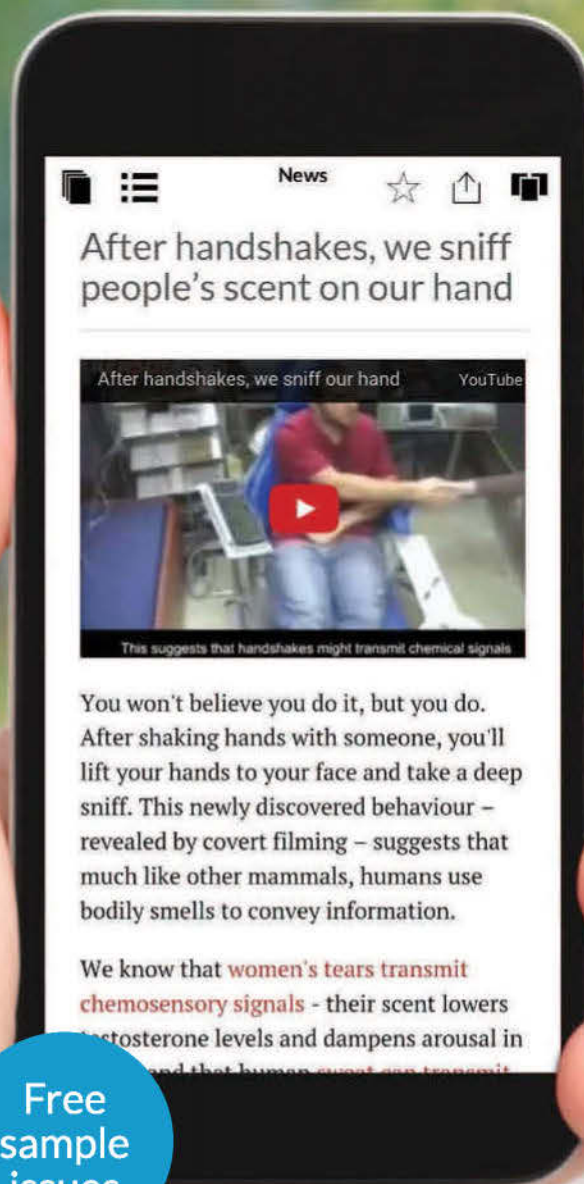
■ Maurice Wilkins won a share of the Nobel Prize for discoveries concerning the molecular structure of nucleic acids, despite what we implied (12 September, p 40).

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TOM GAULD

KEY TO THE SYMBOLS USED IN MY NEW THEORY						
						
SUM	EMPTY SET	MERCURY	BUZZER	FORESTED AREA	OX	DO NOT TUMBLE DRY
						
VARIABLE RESISTOR	SMOG	BRIMSTONE	WINKING FACE	PICNIC AREA	COMET	SINK UNIT
						
ROOK	SHOPPING BASKET	THUNDER-STORM	PRINCE	HELIUM	FREE PARKING	DEATH



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TEXAS high school student Ahmed Mohamed got a ticking off when he showed off his latest creation – a digital clock. Seeing the box of wires and circuitry, an alarmed teacher did what any pedagogue would: assume it was a hoax bomb, call the police and have Ahmed arrested.

The action provoked a media storm with the local authorities facing accusations of Islamophobia, and support for Ahmed and his fledgling love of engineering rolled in, including an invitation from President Barack Obama to visit the White House. The last word on the matter, though, must go to Flavor Flav, erstwhile member of Public Enemy and long-time fan of wearing wall clocks as jewellery. “#IStandWithAhmed”, the rapper tweeted, wearing his signature accessory. “Stop clock blocking!”.

ALSO having problems with technology were delegates to the IFA Consumer Electronics Show in Berlin. Our colleague reports that

the IFA show organisers usually post a big notice in the press room listing all conference times and locations. This year they went high-tech and only put it online – so were kept endlessly busy answering frantic journalists’ requests for help on where they should be running to.

Likewise, at the launch of their new music player, Pioneer staff provided no written information. Instead, guests were given printed cards with the address of a website. Visitors to the site were asked for a password, which was not printed on the card.

Meanwhile, Samsung invited so many people to its conference on the Internet of Things that hundreds had to squeeze into a side room to watch it relayed on a single TV screen. The link crashed soon after the speeches started, leaving everyone in the side room watching a frozen image with no sound. After 5 minutes the

pictures and sound returned, just as a man on stage proclaimed: “We focus on ease of use.”

MORE conference woes: reports broke earlier this month that 29 attendees of a homoeopathy symposium in Handeloh, Germany, were sent to hospital experiencing hallucinations and cramps brought on by 2C-E, a banned hallucinogenic. “It must have been a multiple overdose,” a narcotics official told reporters – though whether that means the attendees took too much of the drug, or too little of it, depends on your point of view.

Foul play was suspected, yet it has since transpired that the conference was led by a student of Samuel Widmer, the Swiss free love guru who endorses the use of recreational drugs as part of psychotherapy.

The *Basler Zeitung* reported that several of Widmer’s devotees had been connected to similar mass poisonings in recent years, including one session that led to the death of two men in Berlin. Police have yet to decide whether to press charges regarding the Handeloh case; for now Feedback advises you to stick to less alternative treatments.

LAST week *New Scientist* explored the influence of emotional vocabulary (19 September, p 41), prompting a call out on Twitter for readers’ suggestions of feelings they lacked a word for, collated under the hashtag #thatfeeling. The results were, in a word, multifarious.

We’re in love with *limerence* for a state of infatuation; we’d quite like to see *zugzwang* popularised for those facing tough decisions; and will remember *lexnesia* “for when you write a word and suddenly it looks weird and you’re not even sure it’s a proper word”.

Less likely to catch on is one reader’s way to describe the strong urge to cuddle someone; they suggest “skin hunger”.

ALSO lost for words is Matt Ashmore, who wanted to describe the use of “accurate if unfamiliar scientific terms” to sell pseudoscientific guff

(12 September). Guy Cox has nothing to offer except further evidence that this has been going on for quite some time. “In the late ‘60s there was a tonic sold in health food shops called Biostrath Elixir,” he reports, “and one of its ingredients was ‘Natrium muriate’.” Evidence, Feedback suspects, that you should always take boasts of ostentatious ingredients with a pinch of salt.

MANSION tax protester Mylene Klass is feeling a new kind of pinch after claiming to have set a giant land crab free to roam on Hampstead Heath in London. The musician told journalists that she found the coconut crab in her luggage when she returned from filming a TV show on the Pacific island of Mogmog, a “gift” from a playful local – or more possibly someone in her marketing department.



The story brought swift criticism from animal welfare officers, who warned that the introduction of the exotic species could threaten native wildlife. As coconut crabs can grow to a metre in length, Feedback imagines this includes Londoners.

Purportedly, the errant crab was last seen rambling near the Men’s Bathing Ponds. Watch your coconuts, gentlemen.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week’s and past Feedbacks can be seen on our website.

“After you’ve exhausted political Latin binomials you could switch to Greek,” says James Chisholm. “Long ago a zoologist colleague referred to politicians as ‘a bunch of coprocephalics.’”

Resistance not futile?

Do people who have recovered from regular tuberculosis have greater immunity to multi-drug-resistant TB?

■ Surprisingly, given the historic nature and the incidence of tuberculosis in some parts of the world, the actual TB bacillus isn't particularly infectious. It is thought that only 10 per cent of people who are infected develop active TB. The vast majority of people exposed to, or infected by, the bacillus will never go on to develop any clinical illness.

For the most part, you need to be exposed repeatedly in, for example, close family units or bad housing, with malnutrition and poor immunity possibly playing a part. In the pre-antibiotic era, a substantial proportion of people with active TB eventually recovered. Even today, a small subset of people with multi-drug-resistant TB will have apparent clinical recovery. So both innate resistance and acquired immunity against tuberculosis seem to exist.

Does a person who has been cured of TB have greater resistance to a new external source (which may or may not be multi-drug-resistant)? A study of more than 600 people with TB in Cape Town, South Africa, indicated that 18 per cent were reinfected. Of these, 14 per cent were reinfected with a different strain. Similar results have been found in trials in China.

It also appears that people who are reinfected are at a higher risk of developing active disease than someone who has never had the illness before. So exposure to TB doesn't appear to boost resistance to the disease.

Gillian Coates
Trefor, Anglesey, UK

Clockwise

Do all climbing plants such as my morning glory grow clockwise, and if so, why?

■ Your questioner is fortunate in not having bindweed in their garden. A quick look would have shown it to spiral anticlockwise to the sun (that is, when looked at from below), as do all *Convolvulus* species. In contrast, honeysuckle spirals clockwise.

He is less fortunate in not being familiar with the work of the comic musical duo Michael

Flanders and Donald Swann, specifically their song *Misalliance*, which describes these plants:

*"The fragrant Honeysuckle spirals clockwise to the sun
And many other creepers do the same.
But some climb anti-clockwise;
the Bindweed does, for one,
Or Convolvulus, to give her proper name."*

The direction of twist isn't derived from the shoot following the sun, nor is it different in the southern hemisphere. As the direction of turn is species-specific, it is likely to be genetic. In 2002, botanist Takashi Hashimoto showed that mutations in the genome of *Arabidopsis thaliana* caused clockwise spiral growth in root hairs that are normally straight. Similar mutations could be responsible for opposite helices.

The original mutation would have conferred an advantage on

climbing plants, whichever way they coiled, giving them the ability to climb higher toward the sun on the stems of other plants. If there is a herbicide out there

"The direction of twist is not derived from the shoot following the sun. It is likely to be genetic"

that can prevent this spiralling, I have a garden full of bindweed just waiting for it.

Norman Doidge
Newton Abbot, Devon, UK

This week's questions

PINKIES

I often find these strange, thumb-sized, pink globular blobs (see photo, far left) just above the waterline along drainage ditches and canals in Borneo and Thailand. What are they? Over time they turn dusty white and fall away.

Michael Fortwengler
By email, no address supplied

BEACH BUN

I found this object on a beach in northern Tasmania (see photo, near left). It weighs 60 grams, is very hard to the touch and it stinks. Somebody suggested to me, because of the evil smell, that it might be ambergris. Is it ambergris? And if not, what could it be?

Christina Bernhard
Launceston, Tasmania, Australia



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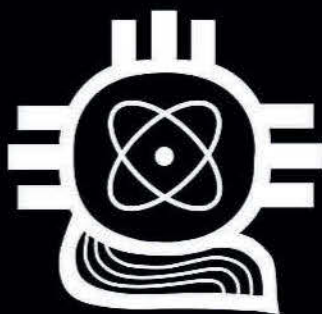
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